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APRIL 1960

City Traffic
Newark's New Downtown Plan
Toll Road Management Problems
Rapid Transit: Present and Future
Transportation and Regional Economics
St. Louis-Area Transportation Plan
Sample Surveys for Highway Needs
Uniform Laws for Urban Traffic
Small Cars and Gas Revenues
Transit Faces the Future
Virginia's State Police
The New Nomads

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

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Traffic Quarterly

TABLE OF CONTENTS, APRIL 1960

City Traffic: An Editorial 127
COLONEL ROBERT C. F. GOETZ

The Effect of Transportation Forms on Regional Economic Growth 129
BENJAMIN CHINITZ

Co-ordinated Transport Planning For the St. Louis Area . 143
R. GILMAN SMITH

Problems of Toll Road Management 161
JOHN PERSHING

Rapid Transit: Present and Future 174
WOLFGANG S. HOMBURGER

The New Nomads 189
SERGE CHERMAYEFF

Developing Uniform Traffic Rules within a Metropolitan Area 199
DANIEL J. HANSON

Virginia State Police Achievements in Traffic-Law Enforcement 212
COL. CHARLES W. WOODSON, JR.

Gasoline Taxes and the Small Car 221
JAMES S. BURCH

Newark Plans Dynamic Changes for Its Downtown Center . 226
HENRY W. CONNOR

Transit Faces the Future 238
WALTER S. RAINVILLE, JR.

The Use of Sample Survey Methods to Estimate Highway Needs 248
DONALD O. COVAULT

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City Traffic

The problem of traffic congestion in large cities is a matter of grave concern. Congestion cannot grow worse for long without serious, damaging results to the important place traffic occupies in a functional city structure.

It is high time in most cities that the present critical situation be measurably improved. It is recognized that any experimental trials will create annoyance and some opposition largely from special interests, but this should not deter the effort.

Any tentative approach or trial run should be undertaken only after appropriate surveys have been made generally in traffic-congested areas, particularly at times when service could definitely be improved for rush-hour, incoming and outgoing passengers.

In general, ideas of trials or changes, if put to test, should be gradual and well considered, with every effort being made to improve the service and retain the good will of the public. To expect satisfactory and profitable service or operation under present conditions appears improbable.

Obviously, movement is a by-word of traffic. Any contribution toward free-flowing traffic will increase the efficiency of streets and meet the public's approbation. It cannot be expected with the confusion of jams, jockeying, parking, slow and fast moving traffic in a block. This widespread chronic condition is tantalizing to the most stoical driver. It is contributory to our high accident rate.

In the present desperate situation of traffic congestion, those in authority should adopt a resolute program of action. There appears to be some reluctance.

Some tentative suggestions follow:

Parking at the curb on designated streets to be totally eliminated at rush hours of the day; both streets and hours can be advantageously and accurately determined.

Maximum use of one-way streets.

Maximum reduction of right and left turns at the cost of slightly further travel.

Both loading and discharge stations to be located on side streets, when loading and discharge warrant special-run buses.

These stations to be determined by bus capacity and probable passenger requirements.

Bus standing time at designated stations to be determined by rate-of-filling-bus capacity.

The matter of routing location of collecting and discharge points would require experienced knowledge after requisite information is made available.

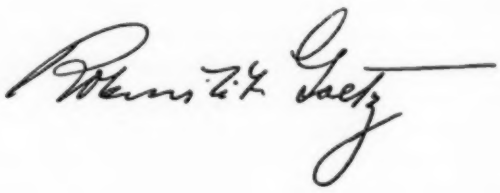
It is believed improvement is possible and can be done without imposition upon any part of the public. If thoughtfully done, with the utmost consideration for every phase of efficient use of our crowded streets, it could well receive the public support. In any event, it seems unwise to perpetuate present unsatisfactory conditions, gradually but surely growing worse. Perpetuance may well portend stagnation.

A fair trial embodying the general idea of these suggestions might reasonably contribute to lowering operation expenses and the daily confusion of the busy street crawl of intolerably jammed buses.

These few suggestions, of the many that warrant trial, are based somewhat on subway operations that provide a pattern of fixed loading and discharge points without undue imposition on its riders.

If we are to make improvement in this growing critical situation, both transit riders and others will necessarily have to make a meaningful and understanding contribution.

No doubt they will.



The Effect of Transportation Forms on Regional Economic Growth

BENJAMIN CHINITZ

Dr. Chinitz is Associate Professor of Economics at the University of Pittsburgh, and Associate Director of the Economic Study of the Pittsburgh Region. This study was initiated last year by the Pittsburgh Regional Planning Association under a combined grant from the Ford Foundation and the Regional Industrial Development Corporation of Pittsburgh, and directed by Dr. Edgar M. Hoover, Professor of Economics at the University of Pittsburgh. Previously, Dr. Chinitz was a full-time member of the staff of the New York Metropolitan Region Study financed jointly by the Ford Foundation and the Rockefeller Brothers Fund. The results of that study are currently being published in a series of volumes by the Harvard University Press. The author's volume, "Freight And The Metropolis," will appear in May of this year. Research underlying this article was done for the New York Metropolitan Region Study and is part of his forthcoming book. Dr. Chinitz holds the M.A. and Ph.D. degrees received at Harvard University.

FOR at least a hundred years or more, manufacturing has grown at a more rapid pace in the rest of the country than it has in New England and the Middle Atlantic states. Each of these areas has suffered a markcd decline in its share of national manufacturing employment. Moreover, all areas of the country—including those whose population growth has been comparatively slow—have gained in manufacturing at the expense of the heavily industrialized Northeast.

In short, manufacturing has pulled away from the Northeast faster than population, and has come to be much more evenly distributed throughout the nation. In the twentieth century, the number of manufacturing workers per 1,000 population has declined in New England, increased but slightly in the Middle Atlantic region, and increased substantially in almost all other areas. (See Table I.)

If we look behind these basic shifts, we can discern two phases, with transportation playing rather a different role in each. The first phase, covering the westward and southward drift of manufacturing during the latter half of the nineteenth century, occurred

when the prevailing tendency in many industries was toward greater geographical centralizing of production facilities. That is, while manufacturing as a whole was coming to be more evenly dis-

TABLE I—PERCENTAGE GEOGRAPHIC DISTRIBUTION OF UNITED STATES MANUFACTURING EMPLOYMENT, SELECTED YEARS, 1860-1954

	1860	1899	1929	1954
United States	100%	100%	100%	100%
New England	30	18	12	9
Middle Atlantic	42	34	30	26
North Central	16	29	35	35
South Atlantic	8	10	10	11
South Central		6	7	9
Mountain and Pacific	4	4	6	10

Source: 1860 figures from George Rogers Taylor, *The Transportation Revolution 1815–1860* (New York, 1951), p. 247. Other figures from U. S. Department of Commerce, Office of Area Development, *Long-Term Regional Trends in Manufacturing Growth 1899–1955* (Washington, 1958), p. 5.

tributed around the nation, individual industries were being drawn more tightly together. The regions that grew fastest during this period did so by attracting certain industries on a large scale.

In the twentieth century, however, the trend has been toward a more evenly distributed production in relation to the distribution of population *in a large number of individual industries*. The southern and western regions that have increased their share of the nation's manufacturing employment in recent decades have done so primarily by increasing their shares of many industries which were and still are concentrated in the older industrial areas. Let us consider each of these phases in turn.

THE CENTRALIZATION PHASE

The declining cost and increasing speed of freight transport in the nineteenth century paved the way for concentration of many manufacturing industries; especially industries once organized on the basis of small plants supplied from local sources and selling to local markets. Whereas, previously, manufacturers had sought ways to economize on transport costs, they now sought ways to reduce production costs. How could they take advantage of lower transport costs to reduce production costs? There were a variety of ways, depending on the kind of industry.

Technological progress in fabrication made available cost-

reducing methods and machines that could be profitably exploited only when production was conducted on a large scale. Reduction in cost of shipping the product to distant markets now made it possible to adopt these techniques. More was saved by using these techniques than was spent on transport costs in distributing the product.

The clearest manifestation of this trend was the substitution of factory for home as the manufacturing unit. "From their predominant position in 1815," writes one historian, "household manufacturers, outside the field of food preparation, had largely disappeared by 1860 in most parts of the country . . . this primitive form of production throve where transportation was most difficult and expensive; it was least able to hold its own wherever canals, steamboats, or railroads were introduced."

But where should the factory be located, now that it was possible to stray from the local market? Often the dominant consideration was availability of superior raw materials. The typical iron works of the early nineteenth century depended upon iron from a nearby bog or mine and upon charcoal fuel provided by trees of the immediate countryside. Once the opportunity for large-scale production appeared, the superior ore and coal resources of western Pennsylvania and Ohio made them attractive as locations for large mills.

Raw-material sources also attracted production facilities away from the local market, independently of the shift to large-scale production. The mere fact that it was now cheaper to ship the product made it possible for the manufacturer to seek out the superior raw material. True, he could also maintain his factory at the market and have the better raw material shipped in from a greater distance. But it was often cheaper to ship the finished product than the raw material because of the reduced weight and bulk resulting from processing.

Whether independently or in combination with economies of scale, the attraction of sources of raw materials proved very strong in many industries. New England and the eastern parts of the Middle Atlantic states did not fare too well in competition for these industries. Of course there were important exceptions. Those processes that relied heavily on imported materials were attracted to port cities, mainly on the East Coast.

Raw materials aside, the favored location of large plants with

far-flung markets was also shifting westward in response to the westward shift of population and buying power. Reduced transport costs made it possible to satisfy national demand from fewer locations, but these locations were nevertheless chosen with a view to keeping the freight bill as low as possible.

The advent of rail transport—which was largely responsible for the sustained reduction in transport costs throughout the nineteenth century—reduced the cost and increased the speed of overland transport relative to water transport. To be sure, the full effect of the change in the structure of transport costs as viewed by the carrier, was not allowed to be reflected in charges as viewed by the shipper.

Instead, railroad managements engaged in widespread discrimination, cutting their rates where they faced water competition and maintaining them where no such competition existed. Points served by water were favored, therefore, and those with no water alternative were made to bear high rates. But the enormous reduction in overland freight costs nevertheless was a greater boon to areas in the interior than to coastal areas.

In time, the inherent cost characteristics came to be more and more reflected in the structure of rates. After the Interstate Commerce Commission came into existence in the late nineteenth century, its activities whittled away at the various discriminations practiced in favor of the old cities of the Northeast. One of the Commission's policies conducive to reducing discrimination was to make distance a more important determinant of the price of freight service.

After the initial spurt of rail, the cost of moving freight by land, relative to the cost of water haul, continued to decline. For one thing, the railroad grid was being filled out. More points were being connected to each other and to the main lines. A manufacturer could count on having facilities for rail transportation in a rapidly increasing number of places.

For another, the operating costs of water transport were rising more rapidly than the operating costs of railroads. Both rail and water carriers confronted steeply rising wage rates as the productivity of labor made rapid strides in other sectors of the nation's economy. But labor costs occupied a lesser position in the rail cost structure than in the water cost structure.

The railroads detracted from the advantages of coastal ports for still other reasons. By promoting the development of land-locked areas, they helped to redistribute the nation's markets so that a smaller proportion of the total was found in places accessible to water transport. Furthermore, the services of water carriers could now be exploited by combination rail-water movements from points farther in the interior. In short, the emergence of a satisfactory alternative to water transport tended to reduce the attraction of the East Coast as a location for plants serving national markets.

THE DECENTRALIZATION PHASE

Until 1929, the relative decline of the New England and Middle Atlantic states was largely matched by relative growth in the East North Central states. The other broad areas of the country also grew faster than the Northeast, but their combined gains were not equal to that of the East North Central region.

Since 1929, while the Middle Atlantic and New England have continued to decline, relative to the nation, the East North Central region has about held its own, while relative growth has occurred in all other areas. We shall hereafter refer to these fast growing areas as the South and West for purposes of brevity.

The main thesis of this article is that the shift in regional distribution of manufacturing between 1929 and 1954 was associated with a reversal of the trend toward geographic concentration of particular industries which had characterized the earlier period, and that transport factors had much to do with this reversal of trend. The South and West have grown more rapidly than the Northeast since 1929, in the main by becoming more self-sufficient in a wide range of industries. As a rule, they have not tightened their hold over industries in which they already dominated by 1929.

This characterization of the changing geographic distribution of manufacturing activities is based on a careful study of data provided in the Census of Manufactures on some 120 categories of industry. For each industry in each of four broad regions—Northeast, North Central, South and West—the actual number of employees was compared to what that number would be if each region had a share of the national total, equal to the region's share of the nation's population. This calculation was made for 1939 and 1954, for comparable industrial categories.

Results of this analysis showed quite clearly that each of the four regions—including the slow-growing Northeast—had reduced its deficiencies in a large number of industries; that is, it had narrowed the gap between actual employment and expected employment on the basis of population. However, since the South and the West had the greatest deficiencies to start with, the trend toward self-sufficiency naturally was a greater boon to these regions than it was to the mature regions.

When we rank industries by the degree to which they have become more evenly distributed around the country in relation to population, we discover that, generally, industries with relatively high freight costs have been more responsive to the decentralization trend. To be sure, all kinds of industries have decentralized; but among those that have resisted the trend there is a much greater preponderance of industries manufacturing high-value, low-weight products. This finding suggests that developments in freight transport may have had something to do with this trend.

Let us see how changes in transport costs and facilities have helped to alter the distribution of manufacturing employment in this manner.

TRANSPORT COSTS AND OTHER COSTS

One reason that the trend toward concentration of industries has been reversed is that the rapid relative decline of transport costs in the nineteenth century did not extend far into the twentieth century. As shown in Figure 1, average rail revenue per ton-mile has been rising in absolute terms during this century; when adjusted for changes in the price level, these ton-mile revenue figures indicate that the downward trend of the nineteenth century was changed into a widely varying trendless movement in the twentieth century. To the extent that movement has occurred, it has been the result of the peculiar cyclical behavior of freight rates, which tend to fall more slowly and rise less rapidly than other prices.

The trend in average revenue per ton-mile is an imperfect measure of the trend in transport costs. Any such average revenue figure reflects not only a change in the price of some given transport service but also a change in the nature of the transport services being performed over the years. There have been two significant changes in

the bundle of transport services being performed, each of which would tend to depress average revenue per ton-mile and hence give it a downward bias as a measure of the change in transport costs.

AVERAGE FREIGHT REVENUE PER TON-MILE ON ALL U. S. RAILROADS, BY FIVE-YEAR PERIODS, 1890-1955

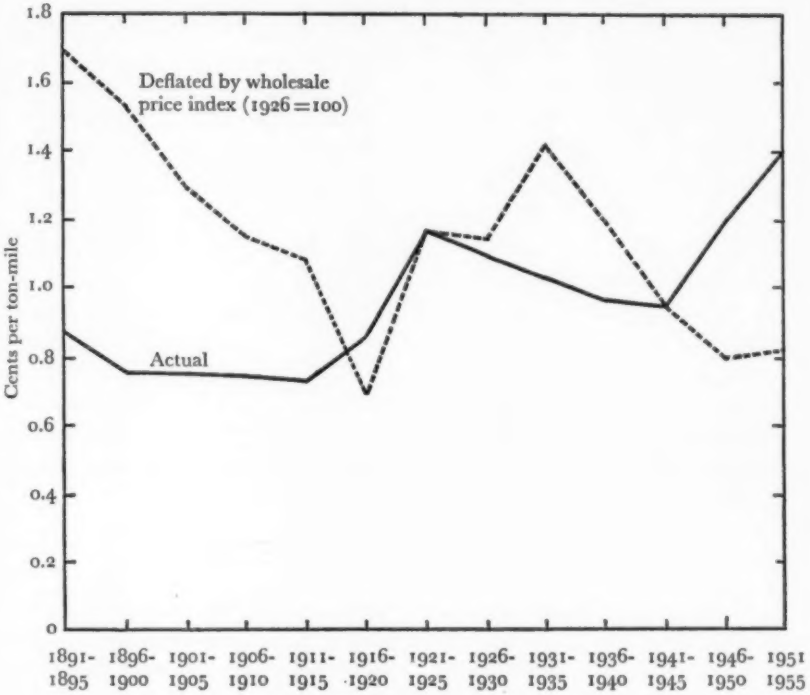


Figure 1.

Sources: Average revenue per ton-mile and wholesale price index from 1890 to 1945, U. S. Bureau of the Census, *Historical Abstract of the United States, 1789–1945* (Washington, 1949), p. 203. Average revenue per ton-mile, 1946–1955, from Association of American Railroads, *Railroad Transportation, A Statistical Record, 1921–1957* (Washington, 1958), p. 24. Wholesale price index, 1946–1955, from U. S. Bureau of the Census, *Statistical Abstract of the United States* (Washington, 1957), p. 324.

One of these is the increasing average haul; the other, the decline in relative importance of less-than-carload traffic. If we could adjust for these biases, therefore, the picture of relatively rising transport costs would be even stranger.

Various attempts have been made to measure more accurately the average increase in freight charges in recent years. Since 1947, the Interstate Commerce Commission has been taking a one percent sample of all waybills on carload freight originating and terminating in the United States. Each waybill provides information on the commodity being shipped, its origin and destination, the revenue received by the railroad for the shipment, and other characteristics of the shipment.

By comparing the revenues received in successive years for shipments with the same characteristics as to commodity and length of haul, it is possible to derive a more accurate measure of the changing level of transport costs than is provided in Figure 1. The results of such a test for the period 1947 to 1954 show that the level of freight rates rose forty-one percent during that period, while the level of wholesale prices rose fourteen percent.

As transport costs rise, relative to other costs, producers seek ways of avoiding transport costs even at the expense of higher production costs, by locating closer to the market. But suppose that getting close to the market means getting farther away from sources of raw materials? Will this not stop the trend? Here, too, we find that developments in transport cost have favored market orientation.

RAW MATERIALS VS. FINISHED PRODUCTS

Freight rates on raw materials and semifinished goods are generally lower than freight rates on finished products. In part, the reason for this is that those who price freight services assume that the demand for transport by shippers of low-value products is quite sensitive to the cost of transport. But in part, the reason is simply a reflection of lower costs. A ton of coal is easier to handle than a ton of steel, and a ton of steel is easier to handle than a ton of automobile.

As nearly as we can tell, this gap in freight rates for different types of products has actually widened over time. By comparing railroad revenues in 1954 to those in 1947 on the basis of the Interstate Commerce Commission one percent sample, it was found that since the war the rates on products of mines—representing a major group of raw materials—have risen less rapidly than rates on manu-

factured products. Less reliable evidence for longer periods suggests a similar tendency in the rate structure. Between 1928 and 1957, the average revenue per ton of mine-products hauled by the railroads increased 63 percent, while the average revenue for manufactured products increased 122 percent.

This tendency apparently resulted from a series of innovations in freight handling, most of which have tended to reduce the relative cost of handling unfinished goods. In addition, the railroads have persisted in their long-cherished practice of discriminating in favor of commodities of low value per ton. Each time they introduced across-the-board percentage increases in freight rates, they made exceptions favoring low-value commodities such as raw materials. As a result, the gap between rates on raw materials and rates on finished products has widened.

The railroads' progressive discrimination in favor of raw materials is manifested in the ratio-trend of revenue to cost, as shown in Table II. While the ratio has fallen for all categories of freight, it has fallen faster for the products-of-mines group than for manufacturers. Paradoxically, the railroads have continued their traditional pricing practices despite the increasing intensity of truck competition for the movement of manufacturers' goods.

TABLE II—RATIO OF REVENUE TO OUT-OF-POCKET COST, CLASS I RAILROADS, SELECTED YEARS

Commodity Class	1939	1947	1951	1955
Products of agriculture	1.35	1.21	1.34	1.30
Animals and products	1.25	1.06	1.17	1.18
Products of mines	1.78	1.32	1.27	1.22
Products of forests	1.53	1.27	1.29	1.31
Manufactures and miscellaneous	2.03	1.65	1.80	1.76
Total	1.72	1.41	1.50	1.46

Sources: Interstate Commerce Commission, Bureau of Accounts, Cost Finding and Valuation: *Distribution of the Rail Revenue Contribution by Commodity Groups—1955* (Washington, 1957), p. 6, and *Distribution of the Rail Overhead Burden by Commodity Groups—1939 and 1947* (Washington, 1949), p. 9.

So far, two factors have been adduced that worked toward greater market orientation of industry: the rise of transport costs relative to other costs, and the rise of transport costs on manufactured products relative to transport costs on raw materials. But a

third and more important factor was the rise of transport costs on long hauls relative to transport costs on short hauls.

LONG HAULS VS. SHORT HAULS

The shipment of freight involves two kinds of costs: terminal and line-haul. Terminal costs are those incurred in the handling of freight at origin and destination. Line-haul costs mean those incurred on the trip between origin and destination, and are roughly proportional to distance. But terminal costs do not vary with distance; they constitute a more or less fixed cost whatever the length of the trip. Consequently, total costs per mile go down with distance because the terminal costs are spread over a longer trip.

Terminal costs depend on many factors, including size of shipment and type of commodity. But on the average, many cost studies have demonstrated that terminal costs are higher for water carriers than for rail carriers, and higher for rail carriers than for motor carriers. When viewed in these terms, it is clear that the sequence of technological development has reduced terminal costs more than it has reduced line-haul costs. As a result, the cost of short hauls has fallen relative to the cost of long hauls. And in this respect the most important event has been development of the truck.

So much for costs. What about rates? Has the change in the structure of costs, as viewed by the carrier, been imparted to the structure of rates, as viewed by the shipper? Our view is that it has—in a variety of ways.

To begin with, if rates did not reflect the change in cost structure, the shipper could exploit the advantages of trucking by operating his private truck fleet. Since almost half of all intercity trucking moves in privately operated vehicles, it is evident that this prerogative has commonly been used. To be sure, resort to private trucking has not always been a real alternative to shippers. For some, the volume and pattern of freight movement have been of a kind to prevent shippers from operating a truck fleet at costs comparable to commercial rates.

Other restraints also have existed. Manufacturers, for instance, have been reluctant to place truckdrivers directly on their payroll because they often consider being involved with the International Teamsters Union a major disadvantage. Despite these restraints on

the expansion of private transportation, many firms have resorted to it.

But the shipper who continued to rely on the common carrier felt the impact of the change in structure of freight costs. Let us assume for the moment that the motor carrier's rate structure did not differ very much from that of the railroad, and that motor-rail competition had no effect on rail rate-structure. Still, the shipper was now being offered a service that was superior to rail, particularly for the short haul.

Take the matter of elapsed time. On the average, according to a recent study, the excess of elapsed time by rail over elapsed time by truck can be reckoned by the following formula: 48 hours plus 8.55 hours for each 100 miles. The figure of 48 arises out of the truck's greater efficiency at origin and destination; the figure of 8.55 from the truck's greater efficiency on the trip between origin and destination.

Saving 48 hours irrespective of length of haul means, of course, that the shipper saves relatively more, the shorter the haul. On a 100-mile trip, truck time is only nine percent of rail time. On a 500-mile trip truck time is twenty-four percent of rail time. Thus, the truck represents a greater boon to the short-haul shipper than to the long-haul shipper.

Aside from time-saving, the truck also offered pick-up and delivery service to the shipper, which the railroad performed only when the shipper had a rail siding. After the railroads instituted pick-up and delivery on less-than-carload shipments, they still required the carload shipper without a siding to pick up and deliver his freight at his own expense.

This additional expense constituted a relatively greater burden on the shipper, the shorter the haul. By the same token, once he could tender his freight to a motor carrier with pick-up and delivery service as routine, his freight costs were reduced, especially for the shorter haul. And for the less-than-carload shipper, this was true whether he shipped by rail or truck.

In these ways, the truck would have reduced the relative cost of short-haul transportation from the standpoint of the shipper, as well as the carrier, even though it had not disturbed existing relationships between rate and distance in freight tariffs. However, the

railroads have attempted to combat motor-carrier competition by rate adjustments, and this fact has resulted in a change in the rate-distance relationship favoring the short haul. It is difficult to demonstrate this assertion by citing changes in rates as quoted in freight tariffs. But other kinds of evidence are available.

PERCENTAGE INCREASE IN RAIL AVERAGE REVENUE PER TON BY LENGTH OF HAUL, 1947-1954

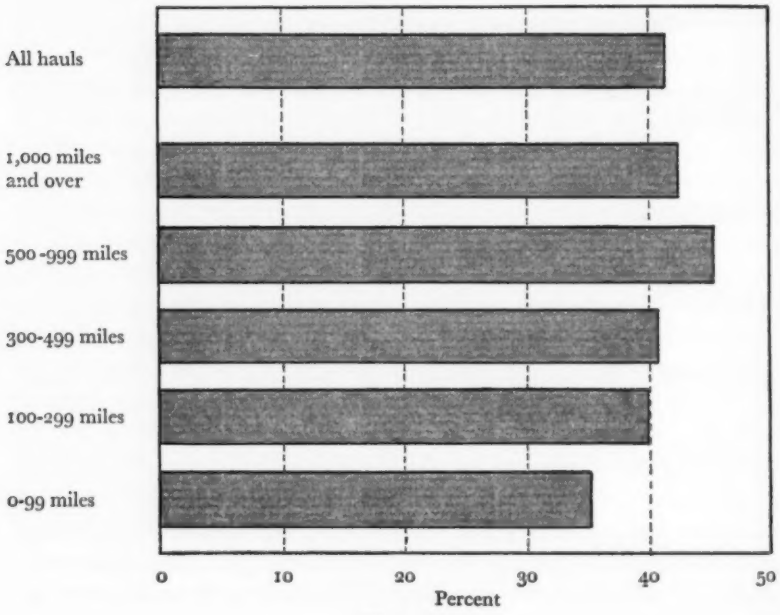


Figure 2.

Source: Benjamin Chinitz, *Freight and the Metropolis*, Harvard University Press, 1960.

For instance, from 1947 to 1954, as Figure 2 indicates, percentage increases in average revenue received by railroads was greater for longer hauls, except for hauls of 1,000 miles or more. These figures, it will be recalled from the earlier discussion, are based on comparison of average revenues in 1947 and 1954 for the same traffic mix. They reflect changes in actual charges rather than in quoted rates.

To be sure, the differences between lengths of haul are not very

impressive. But one can justifiably regard the 1947-54 period as a sample from a longer period stretching back to the 1930's, when the railroads began to react to the pressure of truck competition. If comparable figures covering a longer period were available, they would doubtless exhibit a much sharper divergence in the trend of rates between various lengths of haul.

LARGE SHIPMENTS VS. SMALL SHIPMENTS

Trucking promoted the decentralization of industry not alone because of its impact on short-haul transport costs, but also because it brought down the cost of shipping in small lots relative to the cost of shipping in large lots. By doing so, it cut into one of the advantages of the large-scale producer—the advantage of receiving materials in large lots at lower average freight costs.

The disadvantage suffered by the receiver of small lots of merchandise has changed dramatically with each new phase of the transport revolution. The three major modes of transport—water, rail, and truck—have had distinctly different impacts in this respect. As long as the movement of goods depended on vessels with a total capacity running into thousands of tons, the small producer was at a hopeless disadvantage, by comparison with the large producer whose needs more closely approximated the capacity of a vessel.

The advent of rail reduced the discrepancy, offering the delivery of individual cars with an average capacity of thirty tons. Introduction of the truck with its capacity of about ten tons reduced the spread further. It is apparent, therefore, that new modes of transport, with their increasing divisibility, facilitated the problem of small producers. As a result, the establishment of plants on a smaller scale, closer to the market, became feasible.

If the change in structure of carrier costs favoring small shipments had not been reflected in their rates, innovations would have been of little help to the small shipper. But rates have been affected by changes in costs. For one thing, the lower rates that motor carriers charge for truckload shipments—rates usually approximating those charged by railroads for carload shipments—are applicable on shipments of around 20,000 pounds, for which the railroads charge the higher, less-than-carload rates.

And when the shipper substituted truckload shipments for less-

than-carload shipments, he not only paid a lower rate but also got much better service—an improvement in service far greater than the improvement that resulted from substituting truckload for carload service. For a small shipment moving at less-than-truckload rates, the shipper paid a rate usually no lower than, and often higher than, the less-than-carload rate, but again the service was far superior. At the same time, motor-carrier competition induced the railroads to favor small shipments by providing free pick-up and delivery service for less-than-carload shipments.

All of the transport trends described so far have had the same effect, with respect to the location of industry. They have encouraged a greater degree of market orientation. Partly as a consequence of these shifts in the structure of transport costs, there has been a marked tendency, as observed earlier, for employment in individual industries to become more evenly distributed around the country in proportion to population. On the whole, this trend has favored the relatively underindustrialized areas of the nation.

However, one major development in recent decades—the spread of air freight—has favored the older manufacturing areas. Without doubt, air freight is a greater boon, the longer the haul. Thus it is a factor tending to favor the concentration of industry.

Even so, air freight is not altogether favorable to established centers. In those industries in which such advantages as lower wages have helped less industrialized areas, the increasing speed of freight transport has worked against high-wage areas. With the aid of air freight, manufacturers have strayed as far as Puerto Rico and even Japan, in search of cheap labor.

Co-ordinated Transport Planning For the St. Louis Area

R. GILMAN SMITH

Mr. Smith has been a partner in the firm of W. C. Gilman and Company, Engineers, since 1944, and has specialized in transit, transportation and public utilities since 1916. The transportation survey, of which this article is a condensed review, was completed by the Gilman Company late in 1959. Mr. Smith supervised the survey.

THE St. Louis Metropolitan Area Transportation Survey, 1957-1970-1980, for St. Louis City and St. Louis County, was conducted under specifications prepared by the Citizens' Metropolitan Transit Committee of St. Louis and St. Louis County. These specifications provided for current studies of land use and population with estimates for the future, a determination of the current area-travel volumes and pattern by all modes of transportation, and a projection of such travel volumes and pattern to 1970 and 1980.

Studies and evaluations were required of current area-transit facilities, the present highway network, traffic control procedures, and parking practices and requirements. The objective of the survey was to develop and recommend a transportation plan for the area—a plan designed to accomplish a balanced and efficient use of all existing transportation facilities or of those it might be feasible to make available.

The report, submitted to the Mayor of St. Louis and the Supervisor of St. Louis County under date of August 28, 1959, was predicated on the philosophy that such co-ordinated planning should provide for the following:

1. Expressways and an adequate network of major arterial streets on which the transportation of persons will be by automobile and street surface transit.

2. A traffic regulatory and control system and related street improvements that will expedite the movement of all vehicles and pedestrians with maximum safety.

3. Off-street rapid transit service to the extent justified by potential passenger volumes.

4. A location- and use-pattern of off-street parking facilities co-ordinated with present and proposed expressways and transit (both rapid transit and surface transit) to promote the maximum relief for presently congested surface streets in areas (such as the St. Louis central business district) where it is not feasible to increase street pavement areas.

To implement and make possible such co-ordinated transportation planning for a metropolitan area, and to assist in providing any required financing there should be:

1. An area-wide political agency, or authority, having jurisdiction over the transportation planning (major highways, transit, parking and traffic control regulations) and the administration of this planning, irrespective of municipal or other political boundaries, in order that the co-ordinated facilities may be developed and used to produce maximum community benefit.

2. An area-wide plan to provide such a public agency with a continuing and annual source of public funds, through taxing powers or otherwise, to assist in financing as community benefits any transportation improvements developed by co-ordinated planning but which, even if revenue-producing, will not be self-supporting.

The survey followed the usual pattern with basic economic studies based on 1957, and estimates for 1970 and 1980. The existing (1957) travel pattern was developed by home interviews and external cordon counts. The expanded 1957 zone-to-zone person trips were projected to 1970 and 1980 on the basis of the developed economic data. Within the scope of this article it is possible to summarize only certain total figures, and to highlight certain other features of the report.

POPULATION ESTIMATES

The economic studies made in connection with the survey covered dwelling units, workers, residents employed, and retail sales as well as population. Estimates for population only are summarized later.

With a 21.5 percent increase in cordon-area population, the internal person trips were estimated to increase 47.1 percent. With a 50.4 percent increase in total survey-area population, the com-

bined internal and external person trips within, into and out of the cordon area were estimated to increase 64.3 percent.

Total Transportation Survey Area: (4100 square miles, including St. Louis City, St. Louis County, and adjacent sections of St. Charles, Jefferson and Franklin Counties in Missouri, and Madison and St. Clair Counties in Illinois)	*Population Estimates*			*Percent Increase* 1957 to 1980
	1957	1970	1980	
In Missouri	1,600,248	1,797,768	2,017,413	26.1
In Illinois	474,985	849,686	1,103,281	132.3
Total survey area	2,075,233	2,647,454	3,120,694	50.4

Total Survey Cordon Area: (200 square miles including St. Louis City and immediately adjacent sections of St. Louis County)	*Population Estimates*			*Percent Increase*
	1957	*1970*	*1980*	*1957 to 1980*
St. Louis City	855,914	839,518	865,530	1.1
St. Louis County (portion included)	561,204	716,017	855,830	52.5
Total cordon area	1,417,118	1,555,535	1,721,360	21.5

TRAVEL PATTERN

The travel pattern for the survey cordon area developed total 1957 and 1980 person trips as follows:

	Total Person Trips—All Modes of Travel		
To All Destinations	*1957*	*1980*	*Percent Increase 1957 to 1980*
Internal trips	2,194,775	3,228,336	47.1
West Side external trips	227,525	516,610	127.1
Total	2,422,300	3,744,946	54.6
East Side external trips	155,462	489,128	214.6
Total person trips	2,577,762	4,234,074	64.3
St. Louis Central Business District Oriented trips only			
Internal trips	246,243	312,217	26.7
West Side external trips	8,184	20,281	147.8
Total	254,427	332,498	30.7
East Side external trips	39,648	109,248	175.5
Total person trips	294,075	441,746	50.2

In 1957 the 2,577,762 daily person trips were made by modes of travel as follows:

1957 Weekday Person Trips—Survey Cordon Area—Total

Mode of Travel	*Internal Trips*	*West Side External Trips (Missouri)*	*Internal plus West Side External Trips*	*East Side External Trips (Illinois)*	*Total Person Trips*
As automobile drivers	1,131,673	113,664	1,245,337	69,000	1,314,337
As automobile passengers	666,007	113,861	779,868	68,310	848,178
Total	1,797,680	227,525	2,025,205	137,310	2,162,515
As taxicab or truck pass.	57,977	—	57,977	—	57,977
Total by vehicles other than transit vehicles	1,855,657	227,525	2,083,182	137,310	2,220,492
As transit passengers	339,118	—	339,118	18,152	357,270
Total person trips	2,194,775	227,525	2,422,300	155,462	2,577,762
Percent of total	85.2	8.8	94.0	6.0	100.0

Of these 1957 person trips, 83.9 percent were by automobile with trip origins and trip destinations widely scattered throughout the survey cordon area. While the major area of concentrated person-trip destinations and origins was the St. Louis central business district, only 11.4 percent of the total person trips had destinations or origins in that area, and 37.2 percent of the transit passenger trips were oriented to it, as follows:

Percent of 1957 Weekday Survey Cordon Area Person Trips Oriented to the St. Louis Central Business District

Mode of Travel	*Internal Trips*	*West Side External Trips (Missouri)*	*East Side External Trips (Illinois)*	*Total Person Trips*
As automobile drivers	7.4	4.1	18.8	7.7
As automobile passengers	6.1	3.1	17.3	6.6
Total	6.9	3.6	18.1	7.3
As taxicab or truck passengers	6.1	—	—	6.1
Total by vehicles other than transit vehicles	6.9	3.6	18.1	7.2
As transit passengers	34.9	—	81.9	37.2
Total person trips	11.2	3.6	25.5	11.4

The numerical values of these 1957 central business district oriented person trips, together with their percentage distribution by mode of travel, were as follows:

1957 Weekday Survey Cordon Area Person Trips Oriented to the St. Louis Central Business District

	Internal and West Side Externals		*East Side Externals (Illinois)*		*Total*	
Mode of Travel	*Person Trips*	*Percent of Total*	*Person Trips*	*Percent of Total*	*Person Trips*	*Percent of Total*
As automobile drivers	88,662	35.0	12,962	32.7	101,624	34.6
As automobile passengers	44,050	17.4	11,818	29.8	55,868	19.0
Total	132,712	52.4	24,780	62.5	157,492	53.6
As taxicab or truck passengers	3,520	1.4	—	—	3,520	1.2
Total by vehicles other than transit vehicles	136,232	53.8	24,780	62.5	161,012	54.8
As transit passengers	118,195	46.2	14,868	37.5	133,063	45.2
Total person trips	254,427	100.0	39,648	100.0	294,075	100.0

AREA TRANSPORTATION PROBLEM

The 101,624 person trips (in and out) made by automobile drivers with St. Louis central business district destinations represented something over 50,000 automobiles entering that area on a typical weekday. Some 30,000 of these were long-term or all-day parkers and the balance were short-term parkers. While these automobiles brought in 53.6 percent of the persons (including automobile passengers), most of the balance (45.2 percent of the total) were carried in (or out) by transit vehicles requiring no parking space. These figures exclude automobiles and persons passing through the St. Louis central business district on a typical weekday but having no trip destination in that area.

The decline in transit-use in the St. Louis area has followed the same pattern as in most metropolitan areas. Total transit revenue passengers in 1957 were forty-six percent fewer than those carried in 1950. The existing area transit service was found to be good by currently accepted standards. However, it is all on-street surface with no off-street rapid transit, and therefore cannot compete effectively as to travel time with private automobile use.

With the anticipated future increase in daily person trips—particularly into and out of the St. Louis central business district—transit capable of providing shorter travel times is a necessity if adequate access to, and circulation within, that downtown area are to be maintained. These shorter travel times can be gained only by transit that, particularly in downtown and other congested areas, is off-street and therefore free from interferences and delays caused by other traffic, traffic control devices, and pedestrians.

Such transit conforms to our definition of rapid transit. Experience in Cleveland has shown that transit of this type offers sufficient convenience to induce its use by a substantial proportion of persons now making their entire trips by automobile. This diversion from automobile use—especially for trips into and out of downtown and other congested areas, and for trips made during rush hours—will tend to relieve present traffic congestion and reduce future expenditures required for additional expressways and other highway and parking facilities.

DETERMINATION OF RAPID TRANSIT TYPE

Studies showed that present 1957 weekday person-movements into the St. Louis central business district comprised 23,400 transit passengers and 24,800 automobile drivers and passengers in the one hour of maximum travel volume inbound in the morning, with a similar combined total movement of 48,200 persons in the hour of maximum travel volume outbound in the late afternoon. The outer ends of these person trips—morning origins and afternoon destinations—showed a widespread distribution over the entire St. Louis City and St. Louis County area. For satisfactory area coverage, five to seven radial rapid transit routes were indicated.

These studies also developed the existence of a large volume of person movements which did not enter the St. Louis central business district—north and south movements across the city, and movements into and out of the "Lindell Corridor" (Jefferson to Kingshighway along Lindell and adjacent streets) from nearly all outlying sections of the city.

Other travel characteristics, indigenous to St. Louis, were:

Low maximum-hour passenger volumes on indicated radial routes with a wide area spread.

A rapid drop-off of even these low volumes at radial distances of three to four miles with, however, more than ten percent of the present trips extending out to eight miles and some to twelve miles or more.

An indication that the maximum rapid transit use that could be induced from present automobile owners would be long-distance riding.

Present or proposed expressways in direct competition with rapid transit service along most of the indicated corridors or vectors.

These factors indicated that the primary consideration in selecting a type of rapid transit facility for the St. Louis area would be its ability to provide maximum passenger convenience and service flexibility, as well as overall travel times reasonably competitive with those achievable by automobile. Other considerations were capital and operating costs.

Examination of existing railroad facilities in St. Louis City and St. Louis County indicated that rights of way were inadequate and not properly located to meet requirements for rapid transit service.

Also reviewed were the several air-borne, fixed rail, or track- and pavement-borne type of facilities that are in use or have been suggested or recommended for use to provide urban rapid transit service. These facilities include helicopters, standard rail, the various types of special supported or suspended rail or track (all somewhat inaccurately called "monorails"), buses, and moving belts or sidewalks.

Of the fixed-rail facilities of various types, those on special track structures offer the advantage of requiring little if any land for rights of way. Overhead structures, instead of subways, can be used in the downtown area. These factors represent material savings in construction costs. Of these special type structures, our preference would go to a modernized design of the true suspended monorail that has been operating successfully at Wuppertal, Germany, for nearly sixty years as an integral part of an area transportation system.

In our opinion, however, any type of fixed-rail facility had the following definite disadvantages for the St. Louis area:

Existing and potential low maximum-hour passenger volumes would preclude the economic justification of any fixed-rail structures for certain of the indicated corridors and would limit such structures to comparatively short radial distances in other corridors.

The necessity for extensive motorbus feeder operations requiring a change of transit vehicle for a large proportion of the passengers at all times would increase overall travel times and decrease convenience.

Minimum travel times for the substantial proportion of trips of six to eight miles or longer require express service making few station stops. With fixed-rail facilities of any type, express service requires three, or preferably, four tracks, with increased costs for both construction and operation.

Primarily for these reasons we decided on a one hundred percent motorbus transit network with the rapid transit portions operating on separated-grade, exclusive bus-roadways, or commingled with other traffic on outer portions of existing or future expressways. Local service to areas adjacent to outlying portions of the rapid transit routes could then be supplied by rapid transit buses leaving the special structures or expressways and operating on surface streets—providing a high percentage of "one-seat" rides. Long-distance express service could be furnished with the minimum number of intermediate stops and therefore with minimum overall travel times.

RECOMMENDED TRANSIT SYSTEM

The recommended transit system for St. Louis City and St. Louis County consists of a single co-ordinated operation that offers:

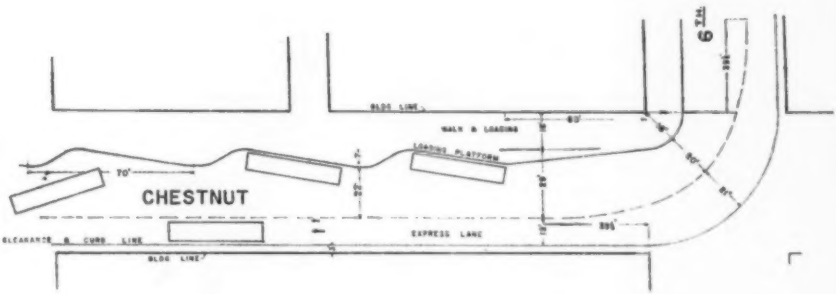
A surface motorbus network operating over 465 miles of streets and highways, that affords better area coverage than the 570 street miles serviced by the present four transit operating companies.

A motorbus rapid transit network providing 106.5 route miles of rapid transit operation over 86 miles of rapid transit facilities (excluding duplicated route miles), of which 41.8 route miles are on grade-separated roadways exclusively for transit buses, and 44.2 route miles represent commingled operation on the outer sections of expressways.

The rapid transit network as shown in Figure 1 consists of five main radial routes (with certain branches); a north and south crosstown route, and a distribution loop in the St. Louis central business district. The special bus roadway structures on the radial routes will be elevated and in most cases off-street and along alleys. The roadway deck will be forty-two feet wide for three-lane operation to permit express bus service. (*Figure 1 is on pages 152–153.*)

The stations will have island platforms (for left hand bus operation) with two bus lanes on each side so that express buses can bypass buses making station stops. The bus ramps will permit rapid transit buses to leave the structure for local delivery or pickup operation on surface streets.

The CBD terminal loop was located on or adjacent to Lucas, 6th, Chestnut and 11th Streets, as that location will place more than seventy-five percent of CBD destined passengers within two blocks of their downtown destinations. The elevated loop structure



Detail drawing of 6th and Chestnut Streets, shown at left of Figure 2 on page 154.

can be entirely on-street, or can be partially or wholly arcaded into adjacent buildings.

The CBD loop will operate clockwise in one direction only with scalloped bus-stop locations adjacent to the inner lane on the bus deck. The complete roadway deck will be sixty feet wide to provide a twenty-three-foot passenger loading sidewalk and three bus lanes (berthing, pull-out, and running). A schematic layout of this loop is shown in Figure 2.

Under the recommended fare-collection procedure described below there will be no fare collection on the CBD loop. The passenger loading platform will provide a covered pedestrian walkway arcade with direct access to the second floor of adjacent buildings.

As shown in Figure 2, the twenty bus-stop berths on each side of the CBD loop and the additional operating lanes will permit

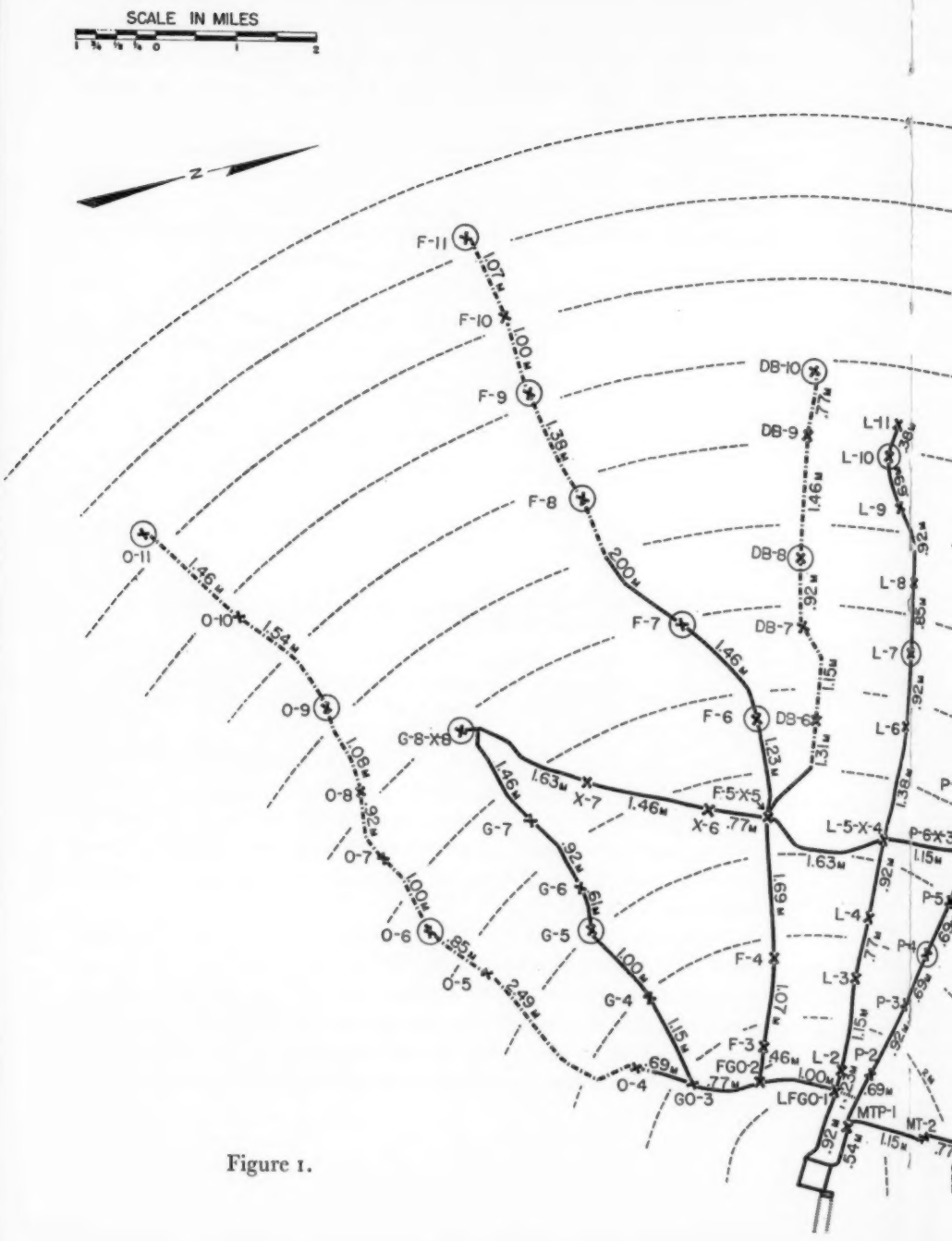

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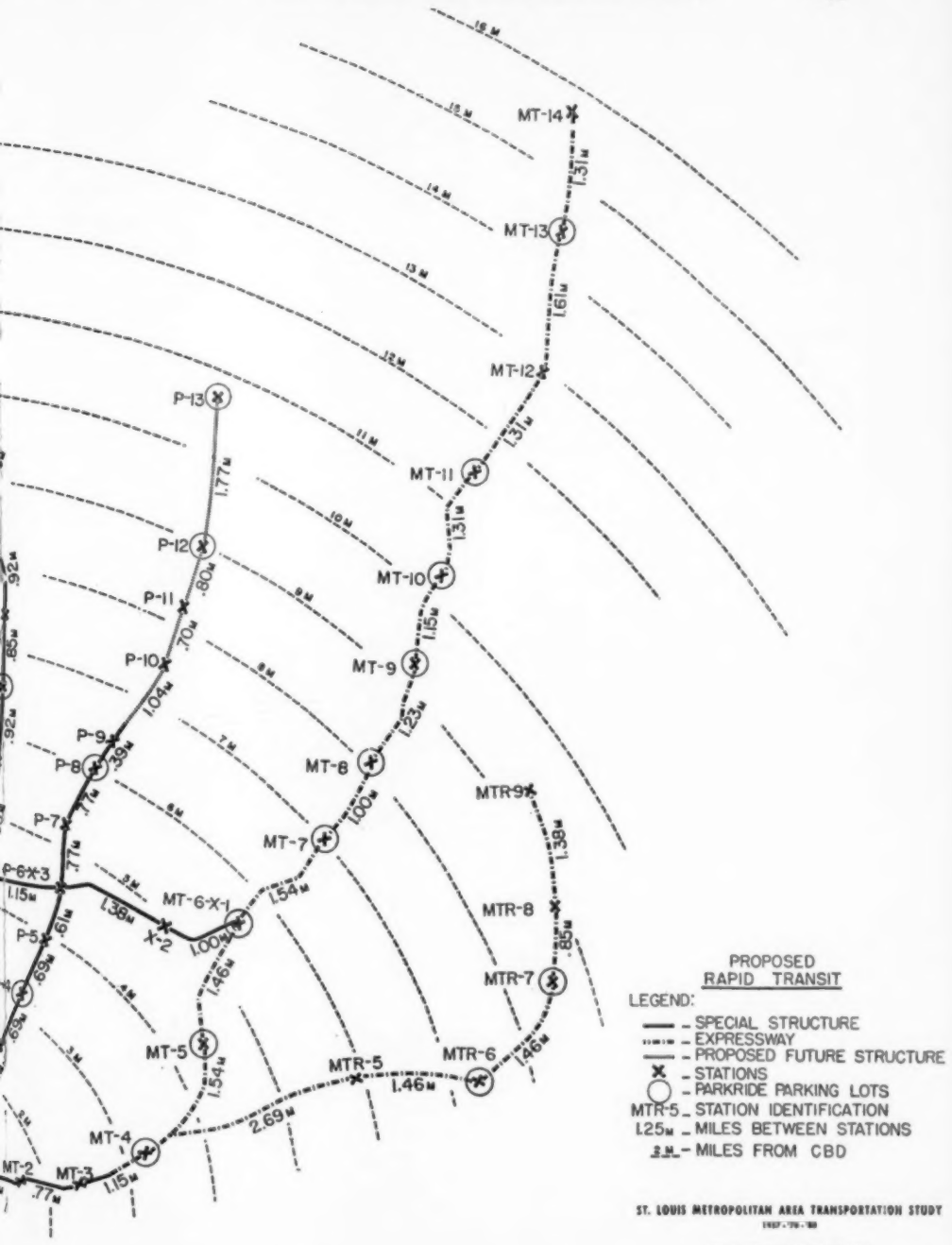
Figure 1.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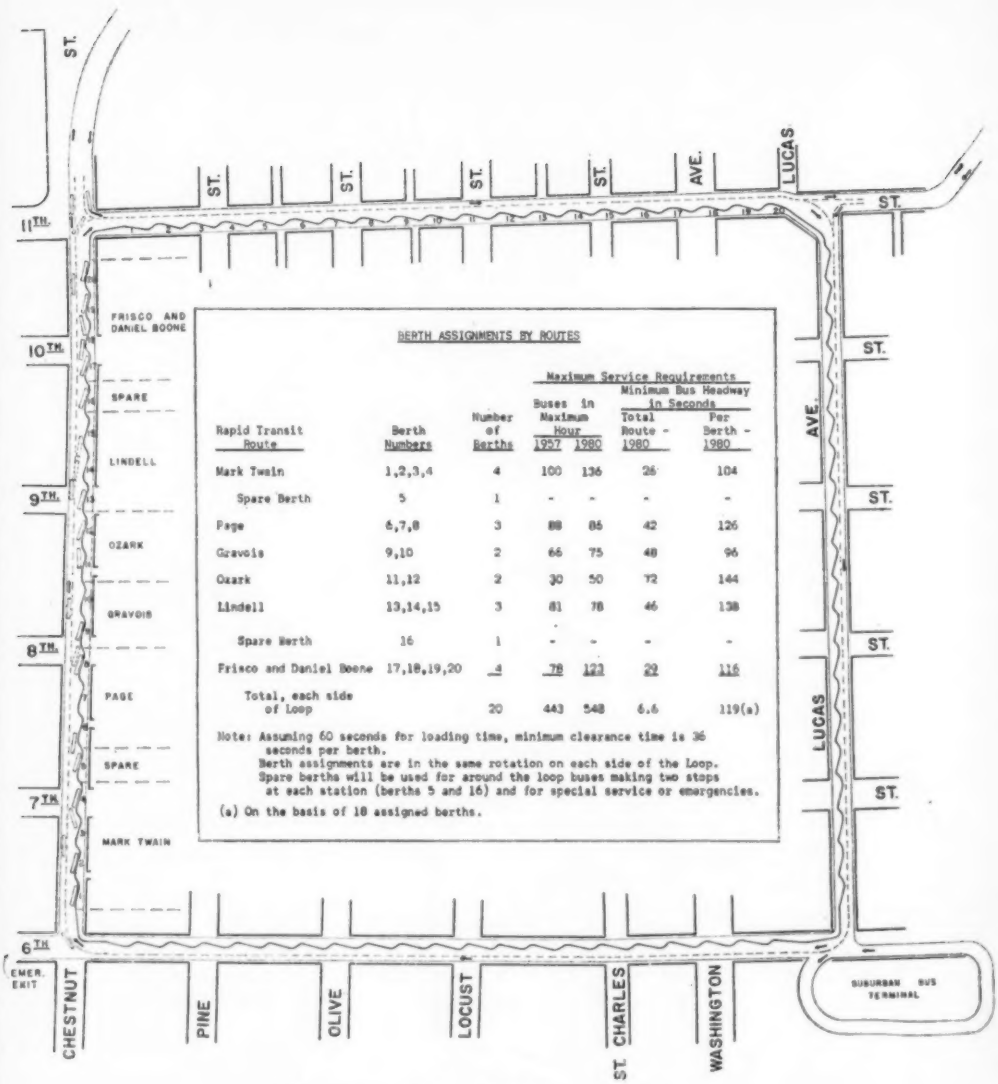
PROPOSED
RAPID TRANSIT
LEGEND:
- SPECIAL STRUCTURE
- EXPRESSWAY
- PROPOSED FUTURE STRUCTURE
- STATIONS
- PARKRIDE PARKING LOTS
MTR-5 - STATION IDENTIFICATION
1.25M - MILES BETWEEN STATIONS
3 M - MILES FROM CBD
ST. LOUIS METROPOLITAN AREA TRANSPORTATION STUDY
W. C. GILMAN & COMPANY



BERTH ASSIGNMENTS BY ROUTES

Rapid Transit Route	Berth Numbers	Number of Berths	Maximum Service Requirements: Buses in Maximum Hour 1957	1980	Minimum Bus Headway in Seconds: Total Route - 1980	Per Berth - 1980
Mark Twain	1,2,3,4	4	100	136	26	104
Spare Berth	5	1	-	-	-	-
Page	6,7,8	3	88	86	42	126
Gravois	9,10	2	66	75	48	96
Ozark	11,12	2	30	50	72	144
Lindell	13,14,15	3	81	78	46	138
Spare Berth	16	1	-	-	-	-
Frisco and Daniel Boone	17,18,19,20	4	78	123	29	116
Total, each side of Loop		20	443	548	6.6	119(a)

Note: Assuming 60 seconds for loading time, minimum clearance time is 36 seconds per berth.
Berth assignments are in the same rotation on each side of the Loop.
Spare berths will be used for around the loop buses making two stops at each station (berths 5 and 16) and for special service or emergencies.

(a) On the basis of 18 assigned berths.

Figure 2. Schematic layout of CBD loop.

operation of estimated 1980 maximum service requirements of 548 buses per hour, with a resulting average headway of 119 seconds per berth.

TRANSIT ASSIGNMENTS

The twenty-four-hour weekday assignments to transit were predicated on 1957 and 1980 internal and west-side external total person trips of 2,422,300 and 3,744,900, developed earlier. The resulting assignments were as follows:

	1957			*1980*				*Percent Increase 1957 to 1980 in Rapid Transit Assignments*
		Assigned to Rapid Transit			*Assigned to Rapid Transit*			
	Total Person Trips	*Person Trips*	*Percent Total*	*Total Person Trips*	*Person Trips*	*Percent Total*		
CBD Oriented Trips								
By automobile	136,232	26,838	19.7					
By present transit	118,195	94,822	80.2					
Total	254,427	121,660	47.9	332,500	136,544	41.1		12.3
All Other Destinations								
By automobile	1,946,950	7,724	.4					
By present transit	220,923	90,184	40.8					
Total	2,167,873	97,903	4.5	3,412,400	128,656	3.8		31.3
Total-All Destinations								
By automobile	2,083,182	34,562	1.7					
By present transit	339,098	185,006	54.7					
Total	2,422,280	219,568	9.1	3,744,900	265,200	7.1		20.8

The assignment of present one hundred percent automobile trips to rapid transit was predicated on the experience in Cleveland, adjusted to reflect the rapid transit facilities recommended for St. Louis. All assignments were made on the basis of trips between individual zones of trip origins and trip destinations considering trip purpose, time of day and present mode of travel; and were made by individual rapid transit stations to develop passenger volumes and service requirements for the hour of maximum travel volume, average-day base hour, and a twenty-four-hour period.

For the several categories of rapid transit trips, the estimated twenty-four-hour passenger volumes for 1957 and 1980 were:

	24 Hour Weekday Person Trips		
	1957	*1980*	*Percent Increase 1957 to 1980*
Assigned To Rapid Transit			
CBD oriented trips	121,660	136,544	12.3
Lindell Corridor oriented trips	34,176	42,320	23.8
On trunk trips	25,076	26,984	7.6
Interline trips	38,656	59,352	53.5
Total Rapid Transit	219,568	265,200	20.8
Assigned 100 percent to Surface Transit	154,112	118,360	(23.2)
Total to transit	373,680	383,560	2.6
Remainder to automobiles	2,048,600	3,361,340	64.1
Total person trips, all destinations	2,422,280	3,744,900	54.8
Percent Total person trips assigned to transit	15.4	10.2	—

( ) denotes decrease.

The 1957–1980 decrease of 23.2 percent in surface transit passengers represents a continuation of the long-term declining trend in that type of transit, primarily because of automobile competition. Unfortunately, it is not feasible to give every present and potential passenger the benefit of rapid transit. For that reason the estimated 1980 total passengers (rapid transit and surface) are only 2.6 percent more than in 1957, while the passengers assigned to rapid transit are estimated to increase 20.8 percent. The result is that while 59 percent of the total 1957 transit passengers would have the benefit of rapid transit, that percentage will increase to 69 percent by 1980.

As against the 64.1 percent increase in person trips by automobile, the recommended highway improvements evaluated across seven survey cordon-area screen lines showed estimated increases in capacities averaging more than 120 percent on the combined arterial and expressway network, with 48 percent of the 1980 capacity represented by expressways as against 7 percent in 1957. Traffic assignments made to the proposed expressway network for 1980 showed that, along the most heavily loaded sections on five

of the expressways, the maximum hour volumes in the controlling direction of traffic would be from 13 percent to 26 percent less with our recommended rapid transit than such estimated volumes would be with no rapid ransit.

SERVICE REQUIREMENTS

Service requirements for rapid transit were predicated on one-direction passenger volumes from basic assignments by specific routes and stations. The developed inbound maximum hour passenger loads at maximum load points and at the CBD loop by routes were:

	Inbound Maximum Hour Passenger Loads			
	At Route Maximum Load Points		*At the Central Business District Loop*	
Rapid Transit Route	*1957*	*1980*	*1957*	*1980*
Mark Twain	5,215	7,232	5,215	7,232
Page	4,774	4,514	4,731	4,436
Lindell	5,543	5,651	4,649	4,334
Daniel Boone	1,087	1,805	664	1,136
Frisco	3,928	6,293	3,236	5,211
Gravois	4,039	4,615	3,525	3,954
Ozark	1,670	2,957	1,501	2,686
Radial route total	26,256	33,067	23,521	28,989
Crosstown	935	1,917	—	—
Total	27,191	34,984	23,521	28,989
Percent increase 1957 to 1980		28.7		23.2

Variations in the changes in total rapid transit passengers, both as between individual routes and types of trips, are indicative of and reflect the 1957 to 1980 changes in the area travel pattern. The significant figures are the estimated 1980 maximum system load at the CBD loop of 28,989 passengers per hour, and a maximum radial vector load of only 7,232 passengers per hour.

Using a fifty-seat motorbus as an operating unit, rush-hour trips were determined on the basis of average loadings of sixty-five passengers for shorter travel distances, and with a seat per passenger for all longer rides. Base hour bus-trips were based on average loads not exceeding forty passengers per bus, or on policy headways. The

resulting rapid transit bus requirements, including street surface feeder service by rapid transit buses, were:

	1957	*1980*
Estimated Maximum Hour Bus Trips Required:		
At maximum load point	533	687
At CBD loop	443	548
Maximum Buses Required, Based on Maximum Load Point Loads:—Maximum hour (rush)	416	540
Average Day Base	87	111

Operation of a large proportion of the rapid transit service as express on the bus roadways is essential, because the overall route headways are such that if all buses made all station stops the lines would be tied up.

Running-time estimates for buses, shown below, have been based on a top operating speed of forty miles per hour, with allowances for scheduled station stops and for slowdowns at junction points and while by-passing stations.

TYPICAL RAPID TRANSIT TRAVEL TIMES AND AVERAGE SPEEDS

	From the CBD Loop to Station Indicated				
				Travel Time in Mins.	
Rapid Transit Route and Stations	*One-Way Miles*	*Average Speed Miles per Hour*	*Type of Service*	*By Rapid Transit*	*By Present Express Bus*
Mark Twain					
Grand Avenue	4.2	22.0	Local	11	21
Lucas and Hunt	9.8	29.4	Express	20	45
St. Charles Rock Road	17.6	29.9	Express	35	(a)
Page					
Woodson Road	11.0	27.3	Express	24	48
Lindell					
Kingshighway	4.6	19.7	Local	14	24
Brentwood	9.4	26.9	Express	21	42
Frisco					
Hampton	7.0	26.2	Express	16	30
Holmes Avenue	13.9	30.8	Express	27	53
Gravois					
Loughborough	8.4	29.7	Express	16	33

(a) No present service.

The total recommended transit system with rapid transit was estimated to operate, on the basis of 1957 service requirements, an annual total of 41,758,000 bus miles, or thirty-six percent more miles than were actually operated by the present transit systems in

1958, with maximum vehicle requirements slightly less than 1958 maximum because of the higher average speeds.

RECOMMENDED PROGRAM'S FINANCIAL ASPECTS

The recommended special rapid transit structures were estimated to cost $175,000,000, including financing costs. Since present equipment—much of which is air-conditioned—could be used, no capital costs were estimated for buses, garages, or shops. This transit program included free park-ride parking lots adjacent to twenty-nine rapid transit stations.

Recommended improvements in traffic control devices (mainly signals in place of stop signs) and physical improvements to arterial highways—in addition to the planned expressway program and approved city and county bond issue projects—were estimated to cost $115,000,000. Also recommended was a twenty-year $50,000,000 program for off-street parking structures on the north and south fringes of the central business district.

These would have direct off-street connections with adjacent proposed two-level elevated expressways. These parking facilities, with free transit bus service into and across the CBD (see proposed transit fare structure below) were designed primarily for long-term parkers so as to release interior CBD off-street parking facilities for the use of short-term parkers and permit the elimination of on-street parking in the CBD core area.

A further recommendation was the construction of an off-street suburban and intercity bus terminal with a heliport on the roof. This would be at 6th and Lucas, directly connected with the rapid transit CBD elevated loop and both the Veterans and Eads bridges across the Mississippi River for East Side transit buses.

The financial operating results of the recommended transit program were estimated on the basis of an area-wide zone fare structure for St. Louis City and St. Louis County, with pay-leave fare collection on outbound buses and pay-enter fare collection on inbound buses. The CBD area, including the rapid transit loop, would then become a free ride area—promoting the convenience of transit and reducing delays to transit buses in that area. Fares for most transit trips would be generally comparable to present express bus fares. Also recommended was an unlimited ride transit

pass for $12 a month, to be mailed and billed to each registered purchaser each month.

The financing of construction of the special rapid transit facilities can be done, according to survey estimates and in the opinion of investment bankers, only by a completely tax-exempt agency or authority. This agency could own and operate the entire area transit system, or could lease the rapid transit facilities to a private operator of a co-ordinated system. As recommended in our report, such an agency must have taxing powers by which transit net earnings or rapid transit facility rentals could be supplemented to provide debt-service coverage sufficient to make revenue bonds marketable.

To provide such supplemental revenues, an annual use tax of $20 per year, assessed against every passenger automobile registered in St. Louis City and St. Louis County, was recommended. It was estimated that over the 1960–1980 period this tax would produce $200,000,000. Since estimated transit debt service requirements could be met by estimated transit net earnings plus half of these tax proceeds, some $100,000,000 would remain available for the recommended highway program that otherwise would have to be financed from general property tax levies. To registered owners of passenger automobiles in the city and county the price of the unlimited transit pass would be $10 per month.

It was believed that the off-street parking program spread over twenty years as needed would be self-supporting. No construction cost estimate was made for the suburban and intercity bus terminal, since it was estimated that it would be self-supporting from rentals.

Problems of Toll Road Management

JOHN PERSHING

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OVER-ALL aspects of this question have been considered in recent articles in the *Traffic Quarterly*: "Toll Road Financing,"[1] "Toll Roads and the Interstate System,"[2] "Financing Metropolitan Transportation,"[3] "The National Highway Program,"[4] and "Financing Highway Programs."[5]

In a February 1959 release, the American Bridge, Tunnel and Turnpike Association stated that one of the most interesting developments of early 1959 was the tentative revival of interest in additional toll roads. The *Evening Eagle*, a newspaper of Enid, Oklahoma, in a March 12, 1959, editorial headed, "Oklahoma Missed a Bet on Turnpike Rejection," concluded, "Why not give new thought to a turnpike . . ." The *Engineering News-Record*, in its issue of April 16, 1959, contains an article entitled, "Will Toll Roads Live Again?"

References have often been made to the "team" which is necessary for successful financing of revenue bond projects. The team consists of consulting engineers, bond counsel and investment bankers. I have served on many occasions as a member of such a team. Since hindsight is better than foresight, this article is critical of procedures but certainly not of individuals. The criticism, intended to be constructive, is directed to the team work.

In my experience, the reports of consulting engineers and traffic consultants prepared for financing purposes have been released and acted upon *before detailed consideration* of the matters mentioned in this article. Consideration of such matters should, I believe, be an integral part of the studies that support the estimates. Opportunity

1. April 1958. 2. July 1958. 3. January 1959.
4. July 1959. 5. October 1959.

to see the working synthesis of experts' estimates and reports has given me a clearer picture of the dependence of such reports on factors that have not been critically analyzed.

Three of the basic purposes of such reports are to set forth (a) consulting engineers' estimate of the cost of constructing a project and the time of its completion, (b) estimate of the cost of operating and maintaining the project, and (c) qualified independent engineers' estimate of gross revenues based upon the proposed toll schedule recommended by them, which the borrower customarily covenants to place in effect prior to the opening of the project for traffic. I believe all of these estimates may have been based upon certain unconscious assumptions which, in the future, can be more clearly evaluated.

From the standpoint of underwriters examining the reports and estimates for financing, and from the standpoint of the responsibilities assumed by a borrower, it is important to realize that basic background differences, not always appreciated, shape the problems of management required to operate in the light of the forecasts. These differences control the administrative procedure established by management to produce the results forecast by the reports.

PROBLEMS OF ORGANIZATION

It has been customary at the time of financing for a board or commission with a skeleton staff to review a preliminary organization chart for management during the period of construction and an organization chart for the extended period of operation and maintenance. Where the financing contemplates that the board or commission shall retain independent consulting engineers to prepare plans and specifications, right of way plans, and to supervise construction, it is not customary for the borrower and its consulting engineers *to review together* the consulting engineers' own organization plan for the work and the detailed relationship between the responsible staff members of their organization and the management of the borrower.

During the construction period, close liaison with the consulting engineers, who are under the obligation to prepare final plans and specifications for a project and to supervise its construction, is vital. The services of personnel competent to perform the liaison work

with consulting engineers during the period of construction may not be services of a character which are appealing after the construction phase has been terminated. Detailed consideration of the type of personnel competent for the extended period of maintenance and operation should not be deferred until after construction has been completed.

At the time of planning the financing of any turnpike or other major construction project, the following questions should be carefully considered and the answers provided, not assumed, before bonds are sold:

(a) From what source is the administrative personnel of management to be provided both during the construction period and during the period of operation and maintenance, and what are the opportunities for transition between the two phases and what are the opportunities for reasonably permanent or career service?

(b) Have the character of the borrower and the character of the project to be undertaken been considered fully in connection with the question above?

(c) Has the administrative procedure necessary to be set up by the borrower been considered in the light of manpower available to and in the employ of consulting engineers?

(d) In estimating costs of operation and maintenance, has detailed consideration been given to prevailing classification and wage scales for public employees, and to the cost of promotion and publicity, to the extent that revenue estimates assume the need for a promotional program?

(e) In estimating gross revenues, has every possible attention been given to the relationship of manpower costs to the revenue estimated and to the difficulty of relating promotional and publicity expense to the results sought to be obtained?

These questions should be asked in the light of the following experiences:

TIME AND COST ESTIMATES

I. The estimate of consulting engineers as to the cost of construction and the time of the completion of the project.

Apart from matters that lie in the lap of God, and assuming the ablest consulting engineers, cost of construction of a project and the

time of its completion may be affected substantially by the character of management and by the administrative organization which must inevitably implement the work of consulting engineers. The ultimate cost of construction, as related to estimates of cost, depends upon the orderly analysis of plans and specifications as prepared, the preparation of notices to bidders, the orderly letting of contracts, and the orderly release of notices to contractors to proceed. More important, the guarantee that the work of consulting engineers be performed promptly and in orderly fashion lies only in their professional reputation. The contract for engineering services does not contain a liquidated damage clause fixing a daily penalty for delays.

As a protection to both the borrower and the consulting engineers, the personnel of the borrower, with ability and firmness in discharging responsibilities in the liaison capacity, is essential. And it clearly follows that such personnel must be retained in the light of a clear understanding of the liaison problems. The actual cost of construction and the time of completion are inevitably affected by the orderly acquisition of right of way and the elimination, to the greatest extent possible, of any basis upon which contractors may present claims for damages as a result of delays in acquisition of the right of way, or increased overhead expenses as a result of inability to use manpower and equipment as planned.

I have stated that certain basic background differences, not always appreciated, shape the problems of management. Completion of construction within the time estimated and within cost estimates requires efficiency of management as well as accuracy of estimates. Basic background differences may require different approaches in analyzing engineers' estimates of cost and the time of completion.

As an example, the State Highway Commission of the Commonwealth of Virginia was authorized to issue toll revenue bonds of the Commonwealth for the purpose, among others, of paying the cost of the Hampton Roads Tunnel. The Richmond-Petersburg Turnpike Authority was authorized to issue toll revenue bonds to pay the cost of a turnpike. In each instance the project was required to be constructed in accordance with the design, plans and specifications prepared by independent consulting engineers, also retained to supervise the construction of the project. But the great difference between the two projects from the management and administrative

standpoint lies in the fact that in one instance there was already in existence for the borrower an organized, experienced staff of competent experts, continuing responsibility, established procedures and the benefit of accumulated experience, while in the other instance the management and administrative organization started from scratch.

This basic difference exists in other instances. Luckily, management has been quite successful in such instances. Other large revenue projects in the future may not be so fortunate. It has been customary, in the consideration of consulting engineers' estimates as to time of completion of a project and the annual costs of operating and maintaining the project, to view the estimates in the light of the suggested "organization chart." The good fortune of management has been the result of chance in many instances rather than the result of the consummation of a plan discussed carefully in advance and related to the anticipated responsibilities of *both consulting engineers and management.* Management and its personnel should not be under the burden of producing results which are the responsibility of the consulting engineers and vice versa.

The character of the borrower and the character of the project should be related to *detailed* problems of management. It is ordinarily the obligation of consulting engineers under a trust agreement to prepare all plans and specifications and to supervise construction of the project in question. Depending upon the character of the borrower and the character of the project, management's problems during the period of construction will vary greatly. Large projects, such as the Ohio, Indiana, and Illinois Turnpikes, although financed by newly created agencies, require staff personnel whose responsibilities are such that they may be absorbed into a permanent operating organization. Other projects are smaller in physical size but just as important to the bondholders.

In the performance of their obligations, consulting engineers usually find it necessary to open field offices. The scope of responsibility delegated to the consulting engineers' field offices may vary. If plans, specifications and important engineering documents are drawn in main offices and sent to field offices, the factors of time consumed in mailing, review in the field offices and return to the main office for revisions if necessary, may be extremely important.

In each instance, however, the management organization should be related to the problems of engineering.

AWARENESS OF RESPONSIBILITY

II. Knowledge by the borrower of its administrative responsibilities.

In my experience, I do not know of any instance where a board or commission of a borrower, or the representative of underwriters, has studied, *at the time of the review of consulting engineers' estimates of cost of construction and time of completion*, the proposed specifications which, after contracts are let, control the relationships between the consulting engineers, the borrower and the contractors.

Specifications that control such relationships include the following: prequalifications of bidders; proposal forms; interpretation of approximate estimates of quantities; examinations at the site of the work; preparation of proposals; irregular proposals; proposal guaranty; disqualification of bidder, and delivery and withdrawal of proposals.

In connection with the award and execution of contracts, such specifications cover the consideration of proposals; award of contract; cancellation of awards; return of guaranties; requirements for bonds or other collateral; the execution of the contract; the effect of failure to execute the contract; requirement for Workmen's Compensation insurance, and other related details.

The specifications cover with respect to the scope of the work: the intent of the contract; special work; the alteration of plans; extra work; final clean-up; other matters peculiar to the scope of the work, and the right to have work done by other contractors.

The specifications with respect to the control of the work are of vital importance from an administrative standpoint. They relate to the authority of the supervising engineer; provisions with respect to the deviation from plans; the authority and duties of inspectors; inspection of the work; final inspection and acceptance; claims for adjustments and disputes; provision for an arbiter to decide disputes relative to the interpretation of plans and prosecution of the work.

Important provisions of the specifications relate to the matter of determination and extension of contract time; the effect of failure to complete on time; and most importantly, the method of making

partial payments, and the method of acceptance and final payment for the work.

I believe that a careful review of proposed specifications at the time of *preliminary planning* would serve to highlight many recommendations that could be made as to the proper liaison procedure, the managerial responsibility, the general administrative procedure to be followed and the personnel required in that connection, all of which would be a great protection in the control of orderly progress of construction, in the orderly acquisition of right of way and in the control of both cost of construction and cost of right of way.

Proposed specifications may be old to consulting engineers, but their content should be known and considered by a prospective borrower at the time its management organization is set up, and the management organization should have clearly in mind its own actual responsibilities and the responsibilities of the consulting engineers under the administrative procedure required by standard specifications.

During the course of construction, field conditions inevitably require changes in plans or procedure. Consideration should be given in the *preliminary planning* to the administrative detail by which the borrower is to handle the approval of work orders and supplemental agreements as such documents become necessary. Too many cooks spoil the broth, but complete surrender of responsibility is legally improper and practically unwise. In an administrative set-up, where a borrower does not have its own engineering department as such, work in the field during the construction period requires, from an administrative standpoint, that all direct dealings be between the consulting engineers and contractors.

The consulting engineers, however, should always maintain close liaison with management so that directions and criticisms by management may be made directly to the consulting engineers for handling by contractors. This should be understood as early as possible in planning and the administrative procedure considered. Here again, a careful review by prospective underwriters and the borrower of the proposed specifications controlling such relationships is important. Quality of the work done may depend to a great extent upon the strict discharge of responsibilities in relation to the issuance of work orders and supplemental agreements.

The problems of providing manpower for management personnel and establishing proper administrative procedures are of such great importance that as little as possible should be left to chance and all possible guidance should be provided at the stage of preliminary planning.

EARLY ESTIMATE OF LAND COST

III. Right of Way Acquisition.

Since the orderly acquisition of right of way can seriously affect the ultimate cost of the project, detailed consideration should be given, at the time of *preliminary consideration* of the financing, to the administrative set-up of the right of way department. From what source are the appraisers to be drawn? Are they to be members of the borrower's staff on a temporary basis? Are they to be outside experts and from what source are they to be drawn? How are negotiators to be retained? Are they to be borrower's employees, or are they to be outside independent experts? Is it certain that negotiation and appraisal are completely divorced in their functions, and has the administrative detail in this respect been given careful consideration in advance of the financing?

The usual trust agreement affords protection to the borrower and its bondholders by requiring the borrower, in connection with any right of way or other lands to be acquired, to furnish a certificate that the property is being acquired in the furtherance of the construction of the project and that no prior payment has been made for the same property. Protection is also afforded by the covenant requiring an opinion of counsel that the interest in the property to be acquired is sufficient for the purpose or, in lieu thereof, a requirement that a firm undertaking will be available by a reputable title insurance company to issue its title insurance policy.

In my experience, where the owner and borrower is a newly created body such as an Authority, the administrative procedure for the acquisition of property is not given detailed consideration until after the financing has been completed and funds are in hand. However, I believe that sufficient experience has now been accumulated so that the governing body of such authority or commission, as a part of the basic financial planning and prior to the employment of its administrative staff, should give consideration

to requirements which have been found to be vital in the orderly process of acquiring right of way economically.

The Bureau of Public Roads, by its Policy and Procedure Memorandum dated December 31, 1956, set forth in considerable detail its policies and procedures relating to Federal participation in right of way for which reimbursement is to be requested by states under federal aid procedure. Under the policy set forth in this memorandum, the state or political subdivision engaged in a right of way program is required to give consideration to and set forth certain important procedural matters including (a) a statement as to whether all properties are appraised *prior* to negotiation and, if not, the exception; (b) a statement whether negotiations are to be conducted by the appraisers or by outside negotiators; and (c) a statement as to who approves negotiated settlements and determines when to condemn.

Experience has shown, I believe, that right of way costs in general have greatly exceeded original estimates of such costs at the time of financing. No criticism of any present procedures within my knowledge for the acquisition of right of way is intended. In particular The Richmond-Petersburg Turnpike Authority has been extremely fortunate in the ability and integrity of its appraisers and negotiators. But the borrower, its appraisers, negotiators and property owners may all benefit from a procedure, the purpose of which is known in advance.

As an illustrative example, the usual rate covenant in trust agreements obligates a borrower to place in effect a schedule of tolls recommended by the engineers originally employed for that purpose and restricts the power to modify such toll schedules except as specified. This has been a protection to the borrower as well as to bondholders when pressure comes to modify the toll schedule.

Requests for modifications in tolls have been met by the statement that it lies beyond the power of the borrower to modify tolls except on the conditions stated in advance in the contract with bondholders which may be shown to be absent at the time of the request. Similarly, I believe that the important steps in the administrative procedure for the acquisition of right of way, if fixed by the borrower prior to the necessity for the expenditure of funds for that purpose, will be a great protection to the borrower, its

appraisers and negotiators, and bring economies in land acquisition.

As a suggestion, I believe it would be wise in the future to give consideration to amplifying the restrictions set forth in the usual covenants with respect to the requirements to be in hand prior to the payment for property to be acquired. In addition to a certificate that the property acquired was in furtherance of the acquisition of right of way or in furtherance of the construction of the project, consideration might be given to having the certificate also certify that in connection with property acquired by negotiation and prior to any payment therefor,

(i) the value of such property and damages, if any, were appraised by at least two independent appraisers,

(ii) the purchase price to be paid for such property was negotiated by negotiators independent of the appraisers, and

(iii) the price paid for such property, if in excess of the appraised value and damages, if any, was approved in accordance with the administrative procedure of the borrower provided for that purpose and approved by the consulting engineers.

A detailed consideration of this administrative machinery and recognition thereof at the time of the financing may not afford resulting savings where the value of the property to be taken and damages have been underestimated, but I do believe that it will protect the borrower against pressures and practices that may be embarrassing to it and to its appraisers and negotiators if not understood and guarded against at the outset.

OPERATING AND MAINTENANCE COST

IV. The estimate of consulting engineers as to the cost of operating and maintaining the project.

In any large toll facility, salaries of the toll collection division and the maintenance division are a substantial part of the annual budget of expenses of operation and maintenance. In nearly all of the facilities with which I am familiar, salary scales and classifications of public employees are available for consideration at the time of preliminary planning. Also in nearly every such instance, employees of large, publicly owned and operated facilities benefit by membership in state retirement or pension plans. The wage and salary classifications uniformly contemplate annual increments in the event of satisfactory service.

As an example, the wage and salary classifications applicable to the toll collection division of The Richmond-Petersburg Turnpike Authority follow basically the plan of the State Highway Department and have been considered in the light of similar classifications and wage scales of other facilities. Annual increments, to which competent employees look forward, could result, in the absence of any great turnover in employees, in an annual increase of from four to five percent of the payroll. The payroll of The Richmond-Petersburg Turnpike Authority in this respect is approximately one-half million dollars. The annual increments alone may result in an annual increase in operating expenses of from $20,000 to $25,000 a year.

Employees normally accumulate at least one day's vacation with pay for each month worked, to provide substantially a two-weeks vacation with pay. As the vacation leaves accumulate, it is obviously necessary to provide personnel to take up the slack during vacation period. Applying these figures to the estimates of annual expenses of operating and maintaining the Richmond-Petersburg Turnpike: the estimate, for financing purposes, of the expenses of operation and ordinary maintenance for the first year of operation was $1,007,000, for the year 1959. This estimate is increased for the year 1960 by $18,000, or a total of $1,025,000, and for the year 1961 the estimate is increased by an additional $15,000 to a total of $1,040,000.

The workable salary and classification scale which ordinarily contemplates annual increments is, therefore, unrealistic in the light of such estimates. This is not the fault of consulting engineers. It resulted from the failure to consider the problem at the outset. The increment for salaries alone more than wipes out the allowances for increased expenses, and the consulting engineers' estimated increases are for *total* costs of operation and maintenance.

PREDICTED REVENUES

V. Traffic Consultants' Estimates of Revenues.

The cost of providing suitable promotional and publicity efforts is, in part, an item of construction cost and, in part, an item of current expenses. It is variously estimated in reports made for financing purposes. This item of cost relates directly to the production of revenues as estimated by traffic consultants. I do not believe it is

estimated always from a realistic standpoint. To what extent do the borrower, its proposed underwriters, consulting engineers and traffic consultants discuss, *as a group*, the anticipated amount to be made available for these purposes and how it is to be expended? This also brings up the important problem of giving consideration to the establishment, in advance of financing, of the extent to which co-operation is assured between the efforts of the borrower, agencies in the areas through which the project may operate, and other agencies affected. Entirely apart from monies made available for the purposes of publicity and promotion, facts may be disclosed at the outset which may render such efforts difficult or impossible of accomplishment.

The erection of billboards and the selection of locations for the erection of billboards may be considered a factor important to the development of traffic. The number of such billboards and the cost of their erection may or may not have been given specific consideration at the time of the preparation of traffic estimates. The problem, however, has a broader significance. The Bureau of Public Roads, Department of Commerce, has promulgated national standards for regulation by states of outdoor advertising signs, displays and devices adjacent to the national system of interstate and defense highways. Public sentiment in opposition to the erection of billboards visible from modern traffic facilities, whether turnpikes or bridges, is increasing. The effort to promote traffic by the use of such billboards is in direct opposition to much public sentiment and may be in direct violation of standards for the regulation by states of outdoor advertising promulgated by the Bureau of Public Roads. In other words, a turnpike may well find itself hung on the horns of a dilemma. It may be damned for not erecting billboards and promoting traffic by such means if traffic is less than consultants' estimates, and it will certainly be damned by many people for erecting billboards to promote such traffic.

In this connection, a question may also be asked of the traffic consultants in the preliminary stages: To what extent do estimates of traffic contemplate specific promotional efforts by the borrower and what expense do the traffic consultants estimate would be necessary to produce anticipated results? In other words, if a substantial publicity and promotional program to develop

traffic is conceived to be necessary, is such a program in any way a condition in the traffic consultants' estimates? If so, it should be specifically stated and considered at the time of such estimates.

Estimates may become facts for the reason that they just turn out that way. There can be much greater assurance that estimates will become facts if the organizational details and human elements required to bring such facts about are also considered in detail at the time of the preparation and analysis of such estimates. It is never safe to assume that people will inevitably be available and perform the responsibilities required to be performed. A much more detailed consideration of the problems of management, in bringing about the results forecast by estimates, must be made in connection with the future financing of major revenue bond projects.

Rapid Transit: Present and Future

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MANY major metropolitan areas will soon need to decide such internal transportation questions as the extent to which mass transit will participate in the urban network. It is important that engineers, planners, and other officials who recommend such policies consider the relative capabilities of the private automobile and mass transit, and the contribution each can make toward the most efficient total system.

Outlined here are characteristics and capabilities of rapid transit systems in general, and of present types and future proposals. An entirely new type of rapid transit vehicle and system may lead to a solution fitting closely the configuration of metropolitan areas.

Central business districts in large urban areas are characterized by concentrated land use, and equally concentrated trip origins and destinations. The value of these districts to their communities is reflected in the high land price and the logical demand that this land be put to concentrated use.

The private automobile alone cannot furnish the transportation capacity and quality of service that dense centers of our large urban areas in their present form require. The cost of a congestion-free highway network and related parking structures would be prohibitive by most economic standards. Besides, such a highway-parking network would withdraw the land from other uses, and thereby lessen the values of a community's dense business center.

Some cities may eventually develop central business districts along other lines suggested by planners. The private automobile, although banned from the very center of the city, would neverthe-

less be the major transportation link. Sufficient parking structures would be built around the downtown area to permit many more persons to reach it by car than heretofore. Within the central district, persons would circulate by moving belts and escalators. However, no community has yet found the way to develop this plan for its central business district.

THE ROLE OF RAPID TRANSIT

The only alternative presently available to the private automobile is a mass transportation system operating on the ground, below it, or just above it. The system differs from the private automobile in that it uses land (in the form of highways or private right-of-way) much more efficiently in movement, and requires little or none of the downtown area for vehicle storage.

While it is generally agreed that mass transit must share in the transportation systems of our large cities, there are many ideas as to the amount and type of mass transit required. Concepts range from ultra-high-speed trains reaching into every nook and cranny of the urban area, to the opinion that buses, competing with other vehicles for street space, operated in a businesslike (self-supporting) manner, will furnish all the transit service that is warranted.

The amount and quality of transit service actually needed in any situation depends on the size and configuration of the urban areas and the travel patterns generated. As a generality, the denser a central business district is, the less it can afford to rely on the private automobile; the denser a residential area is, the more likely it is to need and support mass transit; and, conversely, low densities in employment or residential areas tend to go hand in hand with high automobile ownership and use.

The effectiveness of a transit system can be measured by the number of passengers it attracts. Certainly, if no one wishes to use a transit service, nothing is to be gained in providing it. Such procedure would lead to the misallocation of valuable resources and buses running empty would add to rather than subtract from traffic congestion.

If transit systems are to achieve their purpose they must attract riders, and they must do so by competing with the alternate form of transportation—the private automobile. Most persons moving

in an urban area have the opportunity to choose between these two systems. Generally, it appears, they will decide on the basis of speed, convenience and cost.

In the speed competition, transit systems are usually the loser; time consumed in walking from origin to transit stop, waiting for the transit vehicle, transfer time, if any, and time consumed in walking from transit system to final destination will be computed by the person considering this mode of transportation. In the densest sections of large cities the speed differential becomes less, since the automobile driver is more likely to be delayed in congested streets and to have a longer walk from parking space to final destination. The convenience factor almost always favors the automobile which assures the user a seat and, most of the time, is readily available.

The speed and convenience differential between private car and transit system also varies with the time of day. During peak hours, transit vehicles operating on private right-of-way are affected little, if at all, by the heavier traffic volumes and can generally match the speed of private automobiles more easily than in off-peak periods. Buses on city streets, however, are appreciably slowed as street traffic increases, and are subject to additional delays by increased passenger-loading and unloading at stops. The convenience differential may move in either direction: on one hand, transit service operates at greater frequency during peak periods and passengers generally wait a shorter time for a vehicle; on the other hand, load factors are higher in peak periods, and the chance of a passenger's obtaining a seat is reduced substantially.

Because of the automobile's advantages in speed, convenience and flexibility, the transit vehicle has two strikes against it by the time cost comparison is made. Where costs are approximately equal or even lower for the transit trip, many persons will still use the private automobile because of the convenience and freedom of movement it affords. In large, densely populated cities, high cost of parking automobiles downtown, is perhaps, the primary *cost* factor that attracts riders to transit systems.

It should not be overlooked that two segments of the population have no opportunity to choose between transit and private automobile: those who require a vehicle to conduct their work; and persons who are unable or unwilling to own an automobile. The

latter group contributes considerably to transit riding in large cities, where trip-lengths are greater; in small cities, this group may complete many trips on foot.

Thus, transit systems are most successful in areas of concentrated land use. Not only are they in a better competitive position in relation to the automobile but they also can count on a larger population within walking distance of each route and more potential customers per route mile. Conversely, in residential, industrial and business areas of low-density pattern—half-acre lots per single-family dwelling, factories and shopping centers in one-story buildings surrounded by large parking areas—transit finds it difficult to match service offered by the automobile and can expect less patronage per route mile to support or warrant its operation.

PRESENT RAPID TRANSIT SYSTEMS

"Rapid transit" might be distinguished from local transit as a freeway differs from a city street: that is, its main function is to expedite the *through* portion of passenger trips; it offers no access or service to adjacent land except at stations, just as a freeway provides access and service to adjacent land only at interchanges. To carry the analogy further, rapid transit operations, like freeway operations, are designed to eliminate all possible conflicts of vehicles moving in different directions by separation of opposing traffic streams and grade-separation of cross-traffic movements. Express bus service on freeways qualifies as rapid transit under this concept, although it is subject to delay and possible accidents by mixing with other traffic proceeding in the same direction.

At present, rapid transit service is offered by two types of systems: rail and bus. The chief characteristics of each system are outlined.

Rail systems: These involve single vehicles or trains operating on fixed tracks. Generally, tracks are on an exclusive right-of-way below ground, on elevated structures, or at ground level. Thus potential conflict with other forms of traffic is reduced or eliminated. On commuter railroad operations, potential conflicts with long-distance passenger and freight traffic exist, as well as conflict with highway traffic at grade crossings. A few grade crossings also remain on subway and elevated systems.

Transit vehicles on private right-of-way may be built to larger

dimensions than those permitted on public highways; they may be operated in trains, and may travel at higher speeds than limits imposed on city streets. Automatic signaling can make the system virtually accident proof, and the human factor—which plays such a pervading role in highway safety—can be largely eliminated. It is entirely feasible to operate trains completely automatically just as modern elevators in large office skyscrapers are now designed to function without operators.

The primary disadvantage of rail systems is their high initial cost and maintenance cost. If the system is built at ground level (the alternative with the lowest construction cost) right-of-way must be purchased. If right-of-way costs are to be reduced to a minimum by using public streets, the system must be built below or above ground; in this event, construction costs will be high. Rolling stock represents a large investment; new rail rapid-transit vehicles, currently being built for New York City, cost about $120,000 each, or $1,200 per rush-hour passenger space. Electrical distribution systems, including substations and power houses, must be provided. Maintenance of right-of-way becomes the responsibility of the operating agency.

Present rail systems in the United States and Canada are all of the conventional two-rail supported-vehicle type. Operations are conducted by railroad companies and by urban transit agencies, but there are major differences.

Railroad commuter service has developed along routes built primarily to fulfill long-distance transportation functions. Only incidentally, railroads found themselves faced with the opportunity to carry passengers on shorter runs into the largest cities of their systems. This operation proved profitable before automobile competition. Service standards are quite high: high speeds are made possible by the relatively large distances between stations; most passengers are provided with a seat where long trips are involved; special amenities, such as club cars, are sometimes provided; fares are low (by order of regulatory authorities).

Generally, however, this type of system lacks the convenience of good distribution in downtown areas, since the majority of railroad lines lead into a single terminal, often located at the edge or beyond the limits of the central business district. Commuters are

then required to transfer to other transit vehicles or walk considerable distances to complete their trips. Other problems in railroad commuter-train operation include the slow turn-around of diesel-hauled trains, high labor cost per train, and scheduling to avoid conflict with long-distance passenger and freight operations.

Commuter trains furnish tremendous transportation capacity in many foreign cities, such as London and Tokyo. In the United States, their role is steadily decreasing; some lines are abandoned, service on others is reduced, and still others are transferred to urban transit agencies (for example, Rockaway branch from the Long Island RR to the New York City Transit Authority; Highland Branch from the Boston and Albany RR to the Metropolitan Transit Authority of Boston).

Urban transit rail service was developed specifically to handle urban transportation patterns, and routes are therefore more conveniently located. They penetrate into the center of downtown areas, where a series of stations bring passengers to within walking distance of most destinations (exception: Cleveland). Many routes continue through the city center, not only affording through-service from one side of the urban area to the other, but also permitting trains to be moved through the downtown area without requiring track space for storage or turn-around maneuvers. Trains on those routes that terminate downtown are quickly reversed, since all equipment now used consists of multiple-unit trains which can be controlled from both ends. No attempt is made to provide a seat for each passenger, and during peak hours the ratio of passengers to seats is often as high as two to one.

Labor costs in urban transit rail service are somewhat lower than in commuter railroad service. Trains of ten cars, with a total peak hour capacity of 1,000 passengers, are run with two, sometimes three, operating employees.

The capacity of a rail rapid transit line depends on the maximum length of trains that can be operated, capacity of each car in the train, and minimum train spacing. Perhaps the largest number of persons carried on one track occurs in New York where eleven-car trains, carrying a total of about 1,100 persons during peak periods, move at intervals of ninety seconds. This is equivalent to a rate of 44,000 passengers per hour.

Since World War II, new rapid transit systems have been built to Toronto and Cleveland, while extensions have been constructed, or are under way, in New York, Chicago, Boston, and Philadelphia.

Bus systems: Until recently, bus routes have hardly warranted the classification of rapid transit. In some cities, where local transit routes are very long, operating agencies instituted "express" lines on city streets. With the elimination of many stops, such service seldom can operate at terminal-to-terminal speeds of more than fifteen miles an hour. Now that urban freeway networks in many cities have begun to take shape, the picture is changing; express buses, operating over freeways, now connect outlying areas with central business districts in Los Angeles, San Francisco, Oakland, Atlanta, Dallas, Detroit, Pittsburgh and Philadelphia, among others. Overall speeds are highest where the length of freeway available is greatest.

The maximum convenience offered by bus systems is in the outlying areas where little or no investment in right-of-way is required, and routes may be spaced to reach to within a half mile of most residential areas. Approaching the downtown area, and within it, factors detracting from the overall attractiveness of the service are found: buses must leave the freeways (which generally circumvent the downtown core) and penetrate the central business district on city streets, competing with other traffic; speeds are limited and reliability of service is lessened by the possibility of accidents or congestion. Again, a seat per passenger is often not a standard that can be met, and some passengers may have to stand.

Freeway buses are limited in size by state or local restrictions on highway vehicles, limited in speed by highway speed laws, and are by no means safe from accidents. Even completely safe operation of the bus would not assure that other vehicles in the same traffic stream would find it impossible to collide with the bus. Labor costs are high, one operator being required per vehicle (or per forty-five to sixty-five persons in peak hours).

Since no freeway bus system at this time is operating at near capacity, it is difficult to estimate what a capacity figure might be. It would probably be governed by capacity of the ramps and city streets serving the freeway at the downtown terminal, and the volume of other traffic sharing these roadways with the buses. Probably the highest volume of bus passengers using one facility per

hour is that in the Lincoln Tunnel between New York City and New Jersey:[1] almost 500 buses, with a seating capacity of about 22,000, cross the Hudson River in one direction during the peak hour. This large volume can be handled only because at the New York end these buses are moved directly into and out of a large terminal with ample unloading and loading capacity.

The most attractive aspect of a freeway bus system is the low investment required to initiate operations. Roadways are available and are maintained by other agencies at no expense to the transit operator. Contributions to roadway costs, in gasoline or vehicle taxes, are relatively small; if the operator is a public agency, such taxes may not be required. Investment in rolling stock is less than that for rail service—currently about $25,000 per fifty-two-seat bus. However, the average life of a bus is about ten years, while rail transit vehicles appear to survive for upwards of forty years.

Table I summarizes some of the characteristics of rail and bus rapid transit systems as they appear today. It can be said that a bus rapid transit system may be established with a minimum of initial investment as soon as other agencies have provided high-speed roadways.[2] Labor costs per passenger are considerably higher than in a rail system; other costs would be lower. The service offered would be of less high standard than that of a rail system.

Establishment of a rail system requires large initial financing. No such system could be operationally successful unless it had enough route mileage to carry a substantial number of persons from near their origins to near their destinations without requiring transfers. The length of the initial system would depend on travel patterns of the area involved: in Toronto an initial route of four and a half miles is eminently successful; in the San Francisco Bay Area it has been proposed that the first stage of a new rapid transit system would be at least one hundred and twenty miles long.[3]

1. Cherniak, Nathan, "Passenger Data for Urban Transportation Planning." American Society of Civil Engineers, *Journal of the Highway Division*. Vol. 85, No. HW4, December 1959. Page 50 and Fig. 8.

2. This is being done currently regardless of what decisions concerning rapid transit will be made in various urban areas. Under the federal-aid interstate and defense highway program, funds for urban freeways are continually becoming available and being translated into physical facilities.

3. Parsons, Brinckerhoff, Hall and McDonald. *Regional Rapid Transit, 1953-1955*. A report to the San Francisco Bay Area Rapid Transit Commission. San Francisco, 1956.

TABLE I

COMPARISON OF RAIL AND BUS RAPID TRANSIT CHARACTERISTICS

		Rail rapid transit	*Bus rapid transit*
Initial cost in fixed facilities		High on all parts of system	Little or none
Cost of rolling stock		About $1200 per rush-hour passenger	About $400 per rush-hour passenger
Life of rolling stock		About 40 years	About 10 years
Capacity per track or lane		About 40,000 passengers per hour	Up to 20,000 passengers per hour
Rush-hour passengers per operating employee		Up to about 400	Up to about 65
Operating speeds		High, limited only by design of system and station spacing	Variable, depends on conditions of surrounding traffic stream
Safety		High, through reliance on automatic signals, controls	Variable, depends on conditions of surrounding traffic stream and human factors
Competitive analysis:	Speed	Superior in congested areas; little advantage in low-density areas.	Inferior in congested areas; little difierence in low-density areas.
	Route coverage	Inferior in low-density areas; must rely on feeder service by buses or private automobiles.	Superior in low-density areas; does not require feeder lines.
	Vehicle comfort	Superior, larger vehicles, smoother operations	Inferior, smaller vehicles, operation can be jerky

Proposals for improving rapid transit include recommendations for new or extended "conventional" rail systems (New York, Chicago, Philadelphia, Boston, San Francisco-Oakland, Cleveland and Washington); for completely new types of bus systems (Baltimore, St. Louis, Vancouver, B.C.), and for new types of rail systems. The latter include monorail trains (both suspended and supported varieties), suspended duo-rail trains, and rubber-tired trains running on special concrete roadways.

FUTURE RAPID TRANSIT SYSTEMS

A supported monorail, in the version developed by Wenner-Gren, has been built to slightly less than full size scale at Disneyland. This amusement park installation is performing a highly useful function of subjecting the Wenner-Gren train to continuous operation. Experience gained at Disneyland will doubtless indicate what modifications may be necessary and whether, in the long run, this type of monorail has any substantial advantages over conventional trains.

Suspended trains, either monorail or duo-rail, have been built only for short experimental sections since the grandfather of all these proposals, the Wuppertal monorail, was constructed at the turn of the century. No modern suspended train has been subjected to continuous realistic operation comparable to the Disneyland train. It is difficult to appreciate what the inherent advantages might be in suspending a train rather than supporting it: certainly the sidesway seems to present a more serious problem when the train is suspended; the rail must be continually elevated, where ground-level construction might be permissible; the supporting columns must be taller than for a supported rail where clearance below the structures and train is required.

"Aerial transit," advocated by Henry Norton,[4] consists of rubber-tired trains operating in concrete channels either as single vehicles or in trains. All movements are controlled automatically. It is not proposed to make it possible for aerial transit vehicles to leave their tracks and operate as buses on public highways. No prototype of this type of vehicle or track has been built.

The "conventional" supported two-rail system of the future

4. Norton Henry K. *Aerial Transit in the New York Metropolitan Area.* October, 1955.

may be far from conventional. Modern technology permits the design of lighter rolling stock, with advanced acceleration and braking characteristics compared to subway cars operating on present systems. Where a route is elevated, prestressed concrete can lessen the amount of structure required when compared with the Els of New York and Chicago. Rubber tires, whose use has been amply proven in the Paris Metro, can provide a quieter and smoother ride than steel wheels. Altogether, a new supported duo-rail system could be a great departure from the rapid transit systems built in the past.

All forms of monorail, duo-rail and aerial transit have one important feature in common: they operate *only* on a specially constructed roadway or rail, physically separated from all other traffic. Hence, each system, to be established, requires a high intitial investment (operations being restricted to the trackage constructed), and cannot economically give good coverage to outlying, low-density areas. Conversely, each can penetrate the central business district at high speeds and in a safe manner, without being influenced by downtown traffic conditions.

FREEWAY EXPRESS BUSES WITH EXCLUSIVE ROADWAYS

The use of conventional buses on freeways, with exclusive roadways provided in the most congested areas, has been proposed and described in detail for the metropolitan area of St. Louis.[5] This plan envisions an elevated downtown loop, from which seven bus routes would serve outlying areas, traveling partly on exclusive roadways elevated above city streets and in freeway medians, and partly on freeways and city streets. A total of 41.8 miles of special roadway would be constructed, 1.2 miles of which represents the loop in the central business district; 8.8 miles cover a crosstown artery which would not serve the CBD.

In the downtown loop, the roadway would include continuous loading platforms, sixty feet wide, and pedestrian facilities. The radial and crosstown arteries, forty-two feet wide, would include three twelve-foot vehicular lanes. Construction cost for the 40.6 miles of three-lane roadway is estimated at $121.8 million, for the downtown loop at $7.2 million. The total cost, including on-

5. W. C. Gilman and Company. *St. Louis Metropolitan Area Transportation Study, 1957—1970—1980.* New York, September, 1959. Chap. 7.

structure stations, contingencies, etc., but excluding land, is estimated at $164.45 million.

The service furnished on this system would be of the trunk-line type. It is not suggested in the report that the rapid transit routes be branched in the outer areas. It therefore appears that a prime advantage that the bus holds over the rail rapid transit vehicle—flexibility—has not been fully utilized. It remains to be determined whether construction of an elevated loop in the CBD, however attractive, is acceptable to the public. On the other hand, placing such a loop underground is more expensive, especially if the vehicles are not propelled by electricity. Finally, a system of the type recommended for St. Louis does nothing to reduce the operating labor costs below the level of that found in other bus systems.

It is encouraging to see the approach St. Louis has taken toward the problem of providing rapid transit. The limitations of rail systems appear to have been clearly recognized. The opportunity to integrate rapid transit with freeway systems has been fully developed. With only slight modifications (primarily the branching of express routes to provide direct service to many outlying areas), such a system would fit closely to the traffic patterns found in metropolitan areas.

A NEW CONCEPT IN RAPID TRANSIT

The disadvantages in the type of rapid transit system proposed for St. Louis might well be overcome if research work being presently conducted by the Chicago Transit Authority into the feasibility of an automatic bus is successful. Mr. Walter McCarter, general manager of the CTA, described this project recently as follows:[6]

> This proposal is still in the study stage, but there is ample reason to believe that self-guiding bus trains, traveling at speeds of up to sixty or seventy miles per hour on puncture-proof tires, can be operated in specially prepared exclusive lanes of grade-separated expressways.
>
> The guiding function would be performed either electronically or mechanically by facilities installed in the center of each lane assigned to bus train operation. The trains could be driven by propane, diesel or gasoline motive power, or could be powered by electricity.

6. McCarter, Walter J. *Planning Total Transportation for Metropolitan Areas.* Paper presented at the Cleveland meeting of the American Society of Civil Engineers, May 7, 1959.

There are a number of advantages to be derived from the operation of self-guiding bus trains. Construction costs would be considerably less than for the conventional rapid transit elevated structure, open cut or underground subway. Operating noise levels would be minimized by the rubber-tired wheels. The absence of any imposing above-ground structures, such as required for elevated transit, would be beneficial to adjoining properties. Also it would be relatively simple to install self-guiding bus facilities in existing expressways.

In outlying areas, buses equipped for self-guided train operation could be scheduled as manually guided single units to collect passengers, then assemble at appropriate location and be coupled into trains for self-guided express runs in exclusive rights-of-way.

A new transit vehicle of the type being studied by CTA, which is adaptable to both automatic and conventional bus operation, may prove to be the real solution to the urban transit problem. Such a vehicle has been mentioned on other occasions recently,[7] but its full potentialities have not been explored until now.

The automatic/conventional bus (or "A/C Bus," as it will be referred to here) would have the same general dimensions as a modern diesel bus, built to approximately the same specifications as regards turning radius, motor, etc. In addition, it would have some form of mechanism that would permit it to be guided and controlled in specially constructed tracks. Probably, in the automatic phase of operations the A/C Bus should operate electrically, since these sections would occur in the downtown area and might have to be underground. A further modification would therefore be provision of an electric motor. (Vehicles with both electric motors and diesel engines are found on railroads; in Japan, trolley coaches are equipped with diesel motors to move them across grade crossings with electric railways.)

The configuration of the special tracks would depend on the guidance system developed. It would include a roadway and, perhaps, some form of flanges. The roadway would have to be no wider than the distance between outside wheels. The total width for a two-way track would be in the neighborhood of twenty-four feet.

7. When it was proposed that a monorail line be built between central London and London Airport, objections were made to the erection of an elevated monorail near the approach patterns to the runways. It was then proposed that dual-purpose vehicles be used, which would operate on the monorail to within a short distance of the airport, then continue as conventional buses to the airport terminal.

Thus it might be estimated that the cost of such a structure would be considerably less than the $3 million per mile of a forty-two-foot structure recommended for St. Louis, even when automatic control equipment, electric contact rail, and other appurtenances are included.

If such a system were adopted, the initial step (assuming that, in the meanwhile, the necessary development of vehicle and track had been completed) would be to build a downtown distributor-collector system. This would probably be underground, although routes elevated or on private right-of-way at ground level might be possible and acceptable in some CBDs. Its outer terminals would be located in the median of expressways and freeways near the edge of the business district. With no more than this amount of track constructed (though it must be admitted that this is the most expensive section) the system could begin operations.

Any number of bus routes could be established to connect various parts of the urban area with the central district. Each route would use a freeway for the central portion of the trip. Near downtown, the buses would move into the median and enter the track. From this point, the vehicle would operate automatically into and through downtown. Electronic signals would accelerate, retard, stop and switch the road-rail bus as appropriate.

Outside the downtown area, the track network could be extended in freeway medians (or above them) as traffic conditions and available funds dictate. Conditions to be considered would be traffic congestion on the freeway, time saved by extending the track, and the number of passengers the track would carry. In other words, the system would grow by stage construction, just as freeway systems are being built.

One advantage of the A/C system over the rail rapid transit system would be the lower investment required for maintenance and storage of vehicles. Conventional garages and parking lots would suffice, and no marshaling yards would be needed.

What, then, would the A/C system provide?

1. Automatic service on exclusive right-of-way through the downtown area where traffic congestion is greatest.

2. Automatic, high-speed service on radial sections of routes where freeway traffic conditions are congested, and time savings by use of automatic guidance features become appreciable.

3. A lower initial investment in fixed facilities than for all-rail systems.

4. Opportunity to add to the system by stage construction as changing conditions warrant.

5. No fixed investment in outlying areas; hence, route spacing in these sectors at least as close as current bus routes.

The A/C Bus, if successfully developed, might play an important role in urban transportation networks. It appears to have substantial advantages over a system of buses on freeways, which must move on downtown city streets and on the most congested freeway sections near the central business district. It appears superior to a bus system in which special roadways are provided for express buses to bypass the most congested portions of the city freeways and street system.

It cannot be claimed that the A/C Bus would be able to match a rail rapid transit system in every respect. The employee-passenger ratio is likely to be larger with, consequently, higher labor costs. (However, since the A/C Bus also performs most of the feeder services that must be staffed separately in an all-rail system, such differences may not be as large as might first appear to be the case.) In urban areas already having a rail rapid transit system, extensions of such a system would be more likely to enhance the total transportation network than the superimposition of a different form of rapid transit.

It does appear to be a rapid transit system that can be closely tailored to the configuration of the modern metropolitan area and to the traffic patterns this type of area generates. It demands high investment in fixed facilities only in those sectors where the benefits gained are most substantial; no fixed facilities need be built on those portions of routes where traffic density declines and where conventional buses can operate about as rapidly as rapid transit trains.

It is encouraging to know that some research into this type of vehicle has now begun. One must hope that such investigations will be intensified in Chicago and elsewhere, and that transportation planners will give some thought to the implications that the successful development of such a vehicle might have. They might find in the automatic/conventional type of bus the answer they have been seeking.

The New Nomads

SERGE CHERMAYEFF

Mr. Chermayeff has been Professor of Architecture, Graduate School of Design, Harvard University, since 1953. Previously, he was president and director of the Institute of Design in Chicago, from 1947 to 1951; and Visiting Lecturer, Department of Architecture, at the Massachusetts Institute of Technology, 1951–1952. Mr. Chermayeff was born in the Caucasus, Russia; educated in England, where at the age of twelve, he won the gold, silver, and bronze medals of the Royal Drawing Society and the Yates Thompson prizes in drawing and painting at Harrow. He started designing furniture and interiors in 1922, began architectural practice in London in 1930, and became a Fellow of the Royal Institute of British Architects in 1931. Among his best-known buildings are the research laboratories and administration buildings for the Imperial Chemical Industries, and Gilbeys in Manchester, Huddersfield, and London. He was co-winner with Erich Mendelsohn of a national competition for the Bexhill Pavilion in Sussex. Mr. Chermayeff settled permanently in the United States just before the outbreak of World War II, and is an American citizen. He has written on housing, architectural and art criticism, in the technical press, and lectured extensively in Europe and America. He is a member of the American Institute of Architects, of the International Congress of Modern Architects, a founder-member of the Modern Architectural Research Group in England and of the American Society of Planners and Architects in the United States.

AT this time it is impossible to make any projections into the future without recognizing that not only are we committed to urbanization at an ever rising rate, but that, apparently, we are also equally committed to steadily increasing mobility until such time, in the not too distant future, when mobility may collapse of its exaggerations, and the human habitat, by then almost entirely man-made, will have to stand or fall on the degree of intelligence we begin investing now in the porblems of survival of mankind as we know it.

EDITOR'S NOTE: This article is a composite of a speech made at the Urban Design Conference at Harvard University, Graduate School of Design, in the spring of 1958, and the author's contribution to a conference of Planning for Urban Transportation, held under the auspices of the organization of Cornell Planners in the spring of 1959.

Our exploding population, our continuing industrialization, mean that our escape back into nature and a natural human ecology stands in jeopardy.

THE DAILY TRANSPORTATION GRIND

Here in the United States we may observe results of the most complete industrialization so far achieved by any society, coupled with a high standard of living. We may therefore properly gauge the consequences of surrender of human welfare, now under close scientific scrutiny, to the questionable objectives (that is, questionable without further definition) of economic success, technical ingenuity, and increase in leisure.

The long-ago history of city building was of course the resultant of transportation systems to nodal or focal points—but principally for visitors who had reason to gather there—and this process ran on through the longest stretch of mankind's history. Then the city emerged, however faintly, as an entity, and as a desirable conglomerate: it became only lately the industrial city. When industrial technology was still in its infancy, the nature of transportation expanded to that of the citizenry within, developing only recently as a problem at all. Before that, pedestrians managed pretty well between points of primitive departure and arrival.

'THE LAST THIRTY SECONDS OF HISTORY'

We are now, so to speak, in the last thirty seconds of history—faced with an explosion, both in population and technology simultaneously, when our cities are facing the problem of daily traffic in and out, not for visitors alone, but for the citizenry themselves and mounting quantities of goods. This process has been largely accelerated in the United States, as the laboratory for motor transportation systems, and has created a diffusion-pattern, rather than one of concentration, for the first time in history.

We confront the problem not only of getting things and people tidily together in terms of long hauls and tidily across these conglomerations, but we have to look upon the city, or any great conglomeration of people (in my opinion, the word *city* is obsolete) as a pump of great complexity having a twenty-four-hour cycle. The business of getting people and goods in and out leaves great

vacancies behind for many hours on end—(a fifty percent use of most city spaces for the first time).

We leave behind us half-empty dormitories when we go to work; we come back to the dormitories and leave behind fifty percent, or more if we except downtown, of dead space for the night. Within the day-and-night cycle we form a kind of anti-city movement which seems to me to be anti-urban in the cultural sense, because there is in fact little intercourse possible except for some limited and special interest.

It is not an accident of our time that shopkeepers in one specialty want to get together, that bankers like to get together and administrators like to get together, because finally, the telephone conversation is not a substitute for conversation in person, when big decisions are made. Some of the pretentious architecture we are apt to produce now—symbols at the drop of a telephone receiver—is not working well as symbol. It is very poor stuff, because it is so produced. A much more intimate kind of intercourse has to be gone through before the great civilized or cultural events emerge.

If these observations are all true—and they are broad oversimplifications—let us get to an interesting point: the shape of things. Finally, the place to work, to live and to enjoy recreation, is determined by its shape—what sort of habitat it is. What is the environment within which a living modern man, not an abstract man, can really fulfill his basic functions as well as realize his aspirations?

RAMPANT TRANSPORTATION

It seems to me that one of the most conspicuous facts in contemporary history is that the functions of the city have been made completely subordinate to the functions of transportation. Transportation has exploded a little more loudly and more painfully in our faces than anything else in our highly advanced technical society. It would seem among other things that we must try to put the car into its proper perspective. In terms of how to fit the car into the urban pattern, it certainly is not an acceptable view, in my opinion, that it is every American's prerogative to have the car built into the living room.

Anyone who goes west, for even ten minutes with pedestrian

predilections, suddenly finds that everyone wears automobiles. That is probably why you need two, like boots. However, this does not seem to me to be a good pattern biologically or culturally, or even transportationwise. Surely the car can be put in its proper context within a more balanced framework of total transportation. A high priority for planners or architects is to find a balance between all things that are appropriate in a highly technical and changing society.

To dismiss preconceived notions of how men get together, to discover first the contemporary reasons for getting together in relation to the operative forces of our time, we must take into account the explosive population and not merely accommodate explosive transportation at the cost of everything else. We must zone everything that remains to us on the face of this earth—not only on a metropolitan scale, but on a regional scale, to arrive at an entirely new pattern of relationships appropriate to the function involved.

We are regrouping as a result of our newly developed mobility. In the process we are changing both the social and physical aspects of industrial society. It may be necessary therefore to examine more carefully and to redefine our new "realities." In this transition stage: "Nothing is where it ought to be, Nobody is where he wants to be. . . ."

We must actually deter formless suburbanization. Suburbia is the anti-urb: but it is even more than that, for its meanderings in nature destroy landscape without replacing it with anything tangible in form or substance. It is anti-space in any human or architectural sense of the idea of space.

FACTORS THAT INFLUENCE MOBILITY

We have made much of the problems of traffic. It is necessary first to mention, however briefly, the factors that influence mobility itself.

Increasing autonomy of installations: Mass media of communication, of which TV is the most conspicuous, are producing autonomy for users in information, communication, and recreation, hitherto associated exclusively with city-dwellers. Technological effect on mechanical installations is following the same course: increasing independence from large central sources, and costly distribution networks will accelerate human occupancy of hitherto climatically unfavorable regions.

New technological developments: The harnessing of nuclear and solar energy, chemical agriculture, and efficient extraction of salt from sea-water, among other developments, will inevitably lead to a great deployment of population and production centers through the world—into regions presently empty.

Increased leisure: Electronic computers and industrial automation, together with greater health and longevity, will increase leisure which, coupled with an appetite for change, will make travel possible as a way of life.

Independence from specific location and comfortable travel in portable or mobile dwellings may be expected to increase, and this mobile development will, without doubt, be accelerated by metalurgical advance, war-weapon induced; development of synthetics will make possible lighter, stronger, more portable structures of all kinds.

I believe we are witnessing the emergence of industrial nomads. We may be at the beginning of a new era in human history—the age of deployment and not re-urbanization, thus temporarily reversing the trend of millenia for a brief spell before the exploding population eats up the open spaces.

Personally, I observe these probabilities with profoundest melancholy, but I cannot ignore them. In my remaining life, I shall witness acceleration of the distractions of both our natural unspoilt countryside and man-made habitats, the great towns that I love. This suggests that it is necessary to examine our newly developed mobility more systematically and urbanism less romantically, and devise systems of logic to control our thinking and our politics as well as our traffic.

We have been short-term, opportunist and emergency-minded, with the result that, in fifty years, we have run out of air, road and parking space and have practically bankrupted the rest of our human habitat. The failure, ironically, is in direct proportion to our "technical potential."

URBANIZATION VERSUS URBANITY

Mobility and function: If mobility is a way of life, and deployment of population for various reasons is the probable pattern for the foreseeable future of growing industrialization, we may consider effects on the notion of urbanism, in its classic sense:

It may be that urbanism will apply exclusively to cities of metropolitan dimensions, on a functional basis; or to cities which are historical monuments, on a cultural basis. It is perhaps only in both of these that we shall be able to identify qualities of urbanity as we know them.

Such metropolitan cities may be a constellation of closely spaced residential satellites around a compact core composed of institutional facilities; education and cultural centers; mass recreational and amusement facilities, and speciality commerce. Spaces between may become locations for major transportation exchanges, where fast, long-distance passengers and goods will be transferred separately to appropriately slower, more localized means of transport.

The metropolitan central areas' traffic pattern will have to be predominantly public transit, in spite of dollar-driven suicide pacts like the midtown garages recently proposed for New York City. All else may well be re-grouped into smaller clusters, each cluster deriving a special character and form from its special function, thus repeating the process of past history if not its forms.

It is in these smaller clusters that the private vehicles and road systems might predominate and feed the sub-exchanges to long-distance public transit systems and the long-haul automobile throughways. In both the larger and smaller systems, traffic will be channeled around, over or under the pedestrian precincts, and the integrity of both these domains will be maintained all the way from the smallest residential units to the largest public spaces.

In the metropolitan area, the integrity of public transit, including taxis, may have to be immediately protected against the inroads of private vehicles by the use of appropriate deterrents. The transportation exchanges and sub-exchanges will provide quite naturally the location for private long-haul car parking—graded in cost in direct proportion to distance from the core. These transport exchanges may prove to be major new elements in urban design.

All these new physical entities and arteries of a new civilization must, in any case, be in proper balance and relationship.

Out of the logical solution to the individual elements we can readily imagine and understand, could grow an entirely new framework of reference. Out of this, in turn, could be derived a new physical order for man's habitat, and an entirely new concept of

urbanism. Such an order should be capable of accommodating the "useful new" without destroying the "valued old."

Urbanism, in achieving greater breadth, may gain new stature.

EGOCENTRIC TRANSPORTATION

In the auto-centric American civilization, it appears necessary to stress that the transportation network projected here may not necessarily be composed predominantly of roadways as we now know them. If we re-examine purposes and means of transportation, we may well conclude that the automobile age may be of very short duration. The artificially produced auto-mania may prove less catching than the hucksters hope; and genuine obsolescence, the result of growing good sense, may overcome the artificial follies.

Technical evolution and dire need may spell the doom of the two-toned tyrannosauri, so that the smaller, more adaptable beasts, visible in increasing numbers, may inherit the short-trip roads.

Construction of ever greater highways to carry an increasing number of cars, while providing some immediate advantages, actually aggravates all our urban ills in the long run if there is no tangible barrier to stop traffic flow. We can tolerate the pack of wolves in the open, but we cannot manage them in the sheep-pen.

I suspect that the current large cars will be kept by those who can afford them for a legitimate purpose of luxury travel on the high-roads, much as yachts are today in a special anchorage or dry dock, awaiting the sea cruise.

While not neglecting the development of appropriate urban vehicles, we must examine all transportation techniques to accelerate the development of efficient and economic rapid transit systems, such as the monorail and helicopter, for inter-cluster, inter-urban mass travel to supplement improved railroad transportation, and join all these in a balanced system with interurban transit systems.

In any case, we should aim our "friendly realism" at the vast majority of mankind, which in its imminent industrialization could skip the devices of the unplanned transportation period of older industrial societies.

Underdeveloped countries could achieve traffic order without the pioneers' pains. We are not so fortunate; our own realism must

for some time remain remedial until we can reasonably readjust the enormous and largely damaging attitudes of the private automobile era. We might immediately have a careful look at the existing correctives in our auto-anarchy, which, as they are now applied, are aimed exclusively at the consumer.

It seems obvious that problems of automobile congestion and mayhem depend largely on automobile power, dimensions, and controls. Some restrictions, therefore, at the production end may be in order. It should be noted that the automobile's space occupancy in motion as well as at rest is dependent on such factors. For instance, the "insurance" space needed by the driver of an "easy to drive" car stretches far beyond the car dimensions and specified braking distance.

It may be noted that car redesign requires not only factors of safety, maneuverability, and size limitation in proportion to use, but some correctives in design of controls so that driving a car is not too easy.

MOBILITY AND SPACE CONSUMPTION

We should examine the real cost of mobility related to land use. Our industrial, acquisitive society has already accumulated an unconscionable amount of transportation equipment and dead storage space.

A study is needed to ascertain the real dimensions and cost of all automobile transportation space for storage and servicing, as well as for keeping automotive wheels in motion on the one hand; and the cost of allowing the atrophy of railroads and deterrents to development of new forms of land transportation, on the other. Such a study may reveal that developing industrial civilization requires—in order to overcome its natural infatuation with a newly found mobility—positive counter measures: inducements to stay put, to enjoy the pleasure of tranquility once more. The very factors now accelerating deployment may become instruments of tranquilization.

Functionally, mobility alone may therefore require the redesign of our physical environment, to conform more closely to the requirements of increased dispersion in the immediate future, in the first place; and possibly to reverse the trend, in the second. In either

case, the appropriateness of efficient transportation systems to their various purposes, their proper separation from and insulation against each other, the proper separation and insulation of transportation from areas of rest and work, and the adjustment of our thinking and behavior in respect to mobility will be required.

It seems inevitable that human mobility will, in the immediate future at least, increase in quantity and will become more diversified, and will remain for some time one of the most influential factors in the design of the human habitat.

We may now examine the formal consequences of our mobility. We can immediately recognize new categories in our extended perceptions but, at the moment, we can only guess at the nature of a new synthesis of an increasing number of variables and their effect upon the mind of modern man.

We are accustomed to hearing the cliche, "the human scale," but we fail to recognize our true condition and to specify: which human, at what time, where?

This abstract human now ranges, through his technological extensions, from the slow-moving "pedestrian-equestrian" who built our most memorable monuments, to a "greater-than-the-speed-of-sound" giant striding through his habitat in thousand league boots, with his eyes on vastly extended horizons and, alas, in the process, trampling too much underfoot.

No matter what the actual pattern of the human habitat may turn out to be in the future, we must reckon with a vastly extended spectrum of visual perception of modern mobile man. If he has not yet achieved a perceptibly different condition, he certainly has had experiences denied his ancestors, including the early twentieth-century man.

The space perception of mobile man is related to a suddenly extended space in which motion and speed are new dimensions. To the "near-far" plane, corresponding to the visible surface of the earth, have been added the infinitely great "up and down" and "slow-fast." Our space has become dramatically four dimensional.

We can now move vertically in elevators, become airborne, and enjoy vistas and experience quite unknown to any ancestor except the high mountaineer. Our ancestral visual memories and pleasures are not adequate for our immeasurably extended visual world, and

we do not as yet have the measure of harm we possibly have done ourselves. "Space-time" design, to quote Dr. Sigfried Giedion, has real meaning when related to a mobile, extended humanity.

THE VANISHING PEDESTRIAN

All this presupposes a very careful scrutiny of the whole spectrum of experience as related to mobility, speed, and dimension of the space inhabited. It is only then that we shall be able to reclaim, at one end of the spectrum, the pedestrian world: more than the pedestrian world—the world of the man at rest in the fullest sense of the word. When we lie on a lawn, close to a crocus, we have a worm's-eye view of the world and it is a very beautiful world. When we go up in a jet plane, in another scale, we don't wish to deny anyone the pleasure of this astonishing miracle, this entirely new view of the universe and the joys of the skyscape. All the way from the crocus to the skyscape I wish to have it, and I would rather have all these pleasures than merely two cars in every garage.

I am absolutely convinced that it is not the "city" that is here to stay but conglomerations of people who get together for very good reasons. I hope that we will cultivate the getting together for old and new purposes but not on the horrid "togetherness" level where everybody really begins to hate the others. We don't get together any longer necessarily because we are neighbors; we get together because we have something in common or a task to perform. I am convinced that we are going to regroup, largely because of the compulsions of the rise in population, the rise in technology, and the infinite complexity of our systems. And I don't wish to accommodate any transportation system at the expense of other values.

Developing Uniform Traffic Rules Within a Metropolitan Area

DANIEL J. HANSON

Mr. Hanson has been Traffic Commissioner for St. Louis County, Missouri, since April 1, 1958. Previously, he served as the first Traffic Engineer for Peoria, Illinois between 1953 and 1958. Prior to that time he was Traffic Engineer for the Chicago Motor Club and the City of Champaign, Illinois. He holds both a Bachelor and a Master of Science degree in Civil Engineering. Mr. Hanson is an associate member of the Institute of Traffic Engineers and Highway Research Board, and a Registered Professional Engineer in the states of Illinois and Missouri. He was the 1957 recipient of the nationwide "Getting Results Through Traffic Engineering" Award presented by the Association of Casualty and Surety Companies.

IN the decade between 1950 and 1960, a rural Missouri county has been transformed into part of one of the ten major metropolitan centers in the United States. St. Louis County, an area of 497 square miles, increased its 1950 census population of 405,000 to more than 650,000 in 1960.

Accompanying this rapid growth, many major problems arose. One is the present outmoded governmental structure in St. Louis County. The normal traffic problems related to increased population, rising vehicle registration and mileage, are further complicated by the existence of ninety-eight municipalities presently within the county. These communities vary in size from a population of thirty-five to more than 60,000.

The core of the St. Louis Metropolitan Area is the City of St. Louis, with an area of sixty-one square miles and a population of approximately 860,000. In addition to St. Louis County, two Illinois counties and one Missouri county are usually considered part of the metropolitan complex. Governmental problems are compounded by the fact that the City of St. Louis does not lie within St. Louis County. By special action of the state legislature in 1876, the City of St. Louis was legally separated from the then surrounding rural area of St. Louis County.

The Missouri State Highway Department maintains in excess of 300 miles of major roadways within St. Louis County. Most of these roadways are in unincorporated areas. Thus a total of more than a hundred separate governmental agencies have some degree of authority over traffic regulations and controls in the St. Louis Metropolitan area.

METROPOLITAN ST. LOUIS SURVEY

An exhaustive Metropolitan St. Louis Survey, organized in 1956, analyzed metropolitan matters of major concern: property assessment, tax collection, police service and fire protection, public health, planning and zoning, building regulation and inspection, recreational and park facilities, as well as traffic regulation and control. Results of this study identified the main problem as one of too many local governments, varying in quality of service from excellent to none at all.

The most bitter complaint of the more than 2,000 residents interviewed, concerned traffic delays and the great variance in traffic regulations on adjoining roadways. In numerous cases, individual municipalities, through which the same major roadway passes, had different parking restrictions, speed limits, pavement markings, and even roadway widths. In solving this problem, the survey group had few precedents to guide them.

Toronto, which pioneered a metropolitan-type government in 1954, operates under Canadian laws. Miami, Florida's Dade County has established a similar governmental organization based largely upon the existing county framework. Since the City of Miami is located within Dade County, the same approach could not be followed in the St. Louis area because the City of St. Louis is legally divorced from St. Louis County.

The Missouri constitution offers four alternatives for the City of St. Louis and St. Louis County to adjust their intergovernmental relations:

1. The City and County could merge and become one political entity under the municipal government of the City of St. Louis; or
2. St. Louis could rejoin the County as a separate municipality, in the same way that other municipalities are a part of the County; or
3. The St. Louis corporate limits could be extended by annexing any part of the unincorporated area of the County; or

4. A metropolitan district, or districts, could be established for the functional administration of services common to the area.

The survey group selected the fourth method as the most workable and most likely to win support. Upon petition of thousands of voters living in St. Louis and St. Louis County, a nineteen-member Metropolitan Board of Freeholders was created. The mayor and circuit judges of St. Louis appointed nine freeholders from the City. The county supervisor, county council, and judges of the county circuit court appointed nine freeholders from the County. The nineteenth freeholder was selected from outstate Missouri by the Governor.

DISTRICT PLAN FOR SEVEN SERVICES

The Metropolitan Board of Freeholders completed its permanent organization in May, 1958. In addition to more than fifty regular meetings, the Board and its committees conducted forty public hearings. Board committees held more than a hundred group meetings and heard more than two-hundred witnesses. Many of the meetings and hearings were televised, affording the public an opportunity to see and hear the proceedings.

After a year of study, the Board of Freeholders voted to submit to the public a district plan government. The plan, presented to voters of both St. Louis County and the City of St. Louis in November 1959, created a district consisting of the territory of both the City and County under the name, "Greater St. Louis City-County District."

The plan set up jurisdiction for the district government to cover seven common services: traffic control; regulation of mass transportation; sewer and drainage service; civil defense; economic development; planning service, and co-ordinating service for police information and communication.

For performance of these services, the Greater St. Louis City-County District would have authority:

1. To establish and maintain a system of arterial roads, expressways, and major streets. The traffic flow on this system would be under the exclusive control of the District, and subject to a uniform traffic code designed to relieve traffic congestion and speed the movement of motor vehicles, including public transportation, buses and street cars.

2. To prescribe, fix, and control fares, routings and schedules of mass transit companies; to provide off-street parking facilities, park-and-ride areas, special traffic lanes and other methods designed to encourage increased use of mass transportation, and thereby lessen the number of motor vehicles on the streets during rush hours. Provision is made forownership and operation of mass transportation facilities if and when they become necessary.

3. To take over the metropolitan St. Louis sewer district and extend sewer services to all parts of St. Louis County, now only partially served by existing sewer facilities.

4. To organize a civil defense service, under one centralized administration, with authority over the entire area, for the protection of lives and property of District residents in emergencies created by enemy attacks, storms, floods, and tornadoes.

5. To encourage and co-operate in establishing industrial locations to bring to the area new industries, designed to increase employment opportunities and afford a balanced tax base.

6. To establish and maintain an areawide planning service for coordinating private development and public improvements in accordance with present and future needs; to adopt a comprehensive plan for the proper use of land; the location, character and extent of highways, arterial roads, and transportation routes; off-street parking facilities, park-and-ride areas, schools, parks and other recreational areas.

7. To co-ordinate police services by establishing a centralized police communication and reporting system, a training academy for all policemen, and a modern laboratory for crime detection.

Voters of the City of St. Louis soundly defeated the plan two to one, and the County residents repealed the District proposal by a margin of greater than three to one. Many observers believe that if the proposals dealing with traffic regulation and control had been submitted to the voters independently, they would have received overwhelming approval.

ORGANIZING A DIVISION OF TRAFFIC

The St. Louis County Council and respective administrative departments exercise control only in the unincorporated area. Each of the ninety-eight municipalities has complete jurisdiction over traffic regulations within its corporate limits. Recognizing the seriousness of the traffic situation, the county council passed an

ordinance establishing a division of traffic within the Department of Administration in March, 1957. This ordinance prescribed the powers and duties of the division of traffic as follows:

> Regulation of traffic, including traffic administration, enforcement and obedience to traffic control devices, speed regulations, methods of parking, operation and movement of vehicles, bicycles, pedestrians, push carts, railroad trains, street cars and other moving objects and devices upon the highways, public roads, alleys and streets upon the part of St. Louis County outside of incorporated cities.

This ordinance provides for an eleven-member traffic commission, consisting of nine citizen resident freeholders, the executive director of the planning commission and the traffic commissioner. The traffic commission has jurisdiction over co-ordinating and supervising all traffic activities in the part of St. Louis County outside of incorporated cities. In addition, the traffic commission's jurisdiction includes, but is not limited to, the following powers and duties:

> Co-operation and co-ordination with other governments and agencies on traffic planning and control.
>
> Engineering surveys of present traffic conditions and future needs, including parking.
>
> Development of a master traffic control plan.
>
> Designating the location, type, timing and specification of traffic control devices, including electrical signals, signs, markers and parking meters.
>
> Recommend laws and ordinances to put into effect their studies and findings.
>
> Supervise and be responsible for the operation and administration of the Traffic Violations Bureau and the Office of the Traffic Commissioner.

Selection of the first professional Traffic Commissioner for St. Louis County ended April 1, 1958 when the author, then Traffic Engineer of Peoria, Illinois assumed the duties. Figure 1 indicates the present organizational chart of the St. Louis County Division of Traffic. The traffic commissioner is responsible for the administration and organization of the division of traffic and reports directly to the county supervisor, who is the equivalent of mayor of a city. The supervisor, elected at large for a four-year term, also serves as budget officer for the County government. The seven-member

county council, elected for a four-year term, is composed of a representative from each of the seven geographical districts into which the County has been divided.

The unincorporated area of St. Louis County contains more than 300 square miles, but has only an estimated twenty-five percent of the county's population. While the greater area of the county lies outside its ninety-eight municipalities, traffic congestion and other related ills are mainly found within the municipalities. The major traffic problems exist within those communities near or bordering St. Louis city limits. The basic reason for creating the St. Louis County division of traffic was to develop an effective master traffic plan for the entire county without regard to municipal boundaries.

ST. LOUIS COUNTY DIVISION OF TRAFFIC
ORGANIZATIONAL CHART

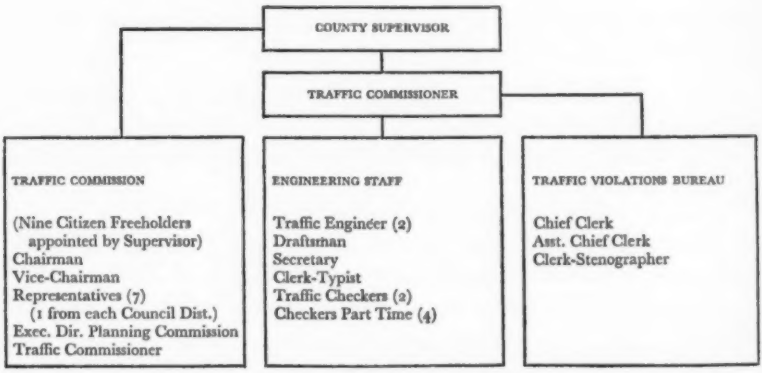

Figure 1.

It was apparent that under present multi-jurisdiction the success of any traffic plan would depend solely upon piecemeal action by all municipalities involved. With this thought in mind, a committee on municipalities and services for St. Louis County recommended to the County Council and the League of Municipalities the following action in regard to highways and traffic:

1. That the County Council, on the basis of a county-wide, comprehensive master plan, designate county through-highways, without regard for the boundaries of cities, towns, and villages, and that the County assume

responsibility for the construction and maintenance of such county through-highways, without regard for location.

2. That the county be given authority to regulate traffic and install traffic-control devices and markings on all county through-highways, without regard for the boundaries of cities, towns, and villages; and that the county counselor examine the State constitution, statutes, and court decisions, and recommend to the county council and the county supervisor such constitutional or statutory changes as are required to accomplish this purpose.

3. That the county council and the county supervisor provide the county traffic commissioner with adequate funds to prepare and keep up to date a master traffic control plan for all major highways in the county; and that the co-operation of officials of cities, towns, and villages be sought in putting into effect promptly the portions of the traffic-control plan pertaining to portions of highways situated within cities, towns and villages.

PRESENT LACK OF UNIFORMITY

Much has been written about the complete lack of uniformity in traffic-control devices and regulation within the St. Louis area. On one major traffic artery, the center-line of which divides two adjoining municipalities, a speed limit of 30 m.p.h. was posted on one side of the roadway, and 40 m.p.h. on the other. These regulations were also enforced with different degrees of emphasis.

Unfortunately, major traffic arteries form the dividing line between numerous municipalities, with the result that in many cases not only speed limits differ, but parking restrictions, pavement markings, and other traffic signs as well. At one time on a roadway carrying more than 30,000 vehicles per day, the pavement surface was badly in need of repair. One municipality immediately improved the north half of the roadway with a three-inch asphaltic resurfacing. The center-line of this sixty-foot pavement is the dividing line between the two municipalities. Several months elapsed before the southern half of the roadway was resurfaced, resulting in a dangerous three-inch ridge during the interim.

Traffic-sign shape, color, size and message, may vary on the same roadway from one municipality to another. Table I indicates the multiplicity of present traffic-control devices on one major roadway that passes through nine different municipalities. This roadway is more than fifteen miles long and varies in pavement-

TABLE I—PRESENT NON-UNIFORM TRAFFIC REGULATIONS AND CONTROL DEVICES ON A MAJOR HIGHWAY IN ST. LOUIS COUNTY, MO.

Municipality	*Mileage Log*	*No-Parking Restrictions*	*Speed Limit (mph)*	*Pavement Marking Color*		*Sign Color (Lettering and Background)*			
				Center Line	*Lane Line*	*Speed Limit*	*Stop*	*Street Name*	*Parking*
A	1. 0.0	7-9 a.m., 4-6 p.m. (both sides) Except Sunday	15, 20, 30	1 Solid Y	Solid W	B/Y B/W W/G	W/R	W/B	R/W
B	2. 0.8	Anytime This Side	30	Double W Plus Y	W Skip	B/W	B/Y	B/W	R/W B/W
C	3. 1.6	7-9 a.m. (E. side) 4-6 p.m. (W. side)	30	Double Y 1 Solid Y 1 Solid W	Solid W	B/W	B/Y W/R	B/W	R/W B/W
D	4. 2.5	7-9 a.m. (E. side) 4-6 p.m. (W. side) Exc. Sat. and Sun.	30	Double Y 1 Solid Y	Solid Y	B/W	B/Y	B/W	G/W R/W
E (S. half)	5. 4.2	7-9 a.m. (S. side)	30	W Skip	Solid W	B/W	W/R	B/W	R/W
F (N. half)		4-6 p.m. (N. side) Exc. Sat. and Sun.	20			B/W	B/Y	W/B1 W/B	B/W
F (Both sides)	6. 4.6	7-9 a.m. (S. side) 4:30-6:30 p.m. (N. side) Exc. Sat., Sun. and Holidays	20 and 30	W Skip	Solid W	B/W B/W	B/Y W/R	B/W W/B	R/W B/W
G (S. half) H (N. half)	7. 7.9	—	40	–	–	B/W	W/R B/Y	B/W W/G	—
G (S. half) I (N. half)	8. 8.8	—	40	–	–	B/W	W/R B/Y	W/B	—
Unincorporated area (S. half) I (N. half)	9. 9.2	—	30 (N. side) 40 (S. side)	–	–	B/W	W/R	W/G	—
I (Both sides)	10. 10.0	—	30	Double Y	Solid W W Skip	B/W B/W	W/R B/Y	B/W	B/W
Unincorporated area	11. 12.7 15.3	—	40	W Skip	W Skip	B/W	W/R	W/G	—

Color Code: Bl-Blue, B-Black, W-White, G-Green, R-Red, Y-Yellow.

width from forty to eighteen feet, and has several independently controlled, timed, and designed traffic-signal installations.

The more prevalent traffic-control devices, such as stop and speed limit signs, may be seen in various color combinations. The size and shape of these signs are also widely assorted, depending upon each municipality's preference. Pavement markings vary from a solid double white line to a single skip yellow line and may be as narrow as three inches or as wide as six inches.

TRAFFIC SIGNAL INDICATIONS

Traffic signal-indications may be found at any quadrant of an intersection. Many are substandard, with only a single-indication per approach and often installed far below the minimum eight-foot height standard. White or green arrows may be used for left-turn indications. The arrow may be placed below the red or yellow lens, above the green, or at the bottom of the signal head—depending in many cases upon an electrician's fancy.

Sequence of operations varies greatly. Some municipalities permit left turns only on a green or white arrow. Other cities allow "Any Way on Green," and many arbitrarily prohibit all left turns at signalized intersections along their major artery. After numerous meetings, metropolitan St. Louis traffic engineers agreed that the standards in the Uniform Manual on Traffic Control Devices should be closely followed.

Several county municipalities and the City of St. Louis, which has well over 300 signalized intersections, have already embarked on a change to the uniform standards. This change-over causes serious re-education problems with motorists accustomed to unorthodox controls. It is obvious, too, that the general public is beginning to appreciate increased uniform traffic signals and the release from over-control.

To emphasize the importance and need for uniform traffic control devices, the St. Louis County division of traffic prepared 400 colored slides depicting the present lack of uniformity. These pictures plainly verify the statement that a picture is worth a thousand words. The slides illustrate the following categories:

Traffic signal indications
Stop signs
Pavement markings

Regulatory signs (speed limit and parking restrictions)
Caution and warning signs
Pedestrian and school crossing protection
Information series signs
Miscellaneous traffic control devices.

Use of these pictures at numerous meetings with municipal officials has resulted in a favorable response. A recent showing before the St. Louis League of Municipalities' monthly meeting was attended by Mayors and other officials from forty county municipalities. This group has already specifically endorsed adoption of the uniform traffic ticket and arrest notification and uniform street name signs. In addition, the League has supported, in principle, adherence to the uniform Manual on Traffic Control Devices.

IMPORTANCE OF UNIFORMITY

What is the basic purpose of uniformity? Certainly it is not merely to standardize for uniformity only. Standardization is useful and effective only as long as it does not bar progress.

Is it not the main goal of uniformity to provide instantaneous, complete understanding of traffic-control devices on the part of motorists and pedestrians? Our citizens are entitled to a traffic system without doubt or confusion. We need a large degree of uniformity to obtain immediate and proper reaction and obedience to the "signs of life."

The general appearance of traffic control devices is readily apparent to every layman. If signs, signals, and pavement markings are not properly designed, installed, and maintained, bad housekeeping and poor traffic engineering administration are immediately indicated. In addition a false sense of security may develop creating undue hazards.

STREET NAME SIGNS

Our first attempt toward uniformity in traffic control devices has been the development of a street name sign program. The St. Louis County Highway Engineer, started the project when a request was made to the county to allocate funds for bringing street-name signs up to date in the unincorporated portions of the county. With $30,000 earmarked for the first phase of the program,

minimum standards were determined on the basis of the established color combination for interstate directional and informational signs —white letters on a green background, with reflectivity for night visibility. The County program will be completed during 1960 with the installation of new street name signs at every intersection along 800 miles of roadway in the unincorporated area. The entire project will cost more than $100,000 when completed. The county was also able to break precedent by receiving state highway department approval to install the new street-name signs at the intersection of all county and state maintained highways.

The St. Louis County Division of Traffic has been acting as a clearing house for this program and is helping each community with its specific problems and details involving the updating of their street name signs. The City of St. Louis is installing identical reflectorized street-name signs and to date fifteen County municipalities have followed suit. The City of St. Louis, with an area of sixty-three square miles and more than 1,100 miles of streets, will spread its street-sign program over several years.

Gaining acceptance of this uniformity is often difficult. Some municipalities wish to keep a particular design or color combination because they regard it as a mark of individuality.

1955 BOND ISSUE PROGRAM

A 1955 County Bond Issue program, provided approximately $34,000,000 for major roadway improvement and construction within the county, disregarding municipal boundaries. Under existing laws, upon completion of any project, traffic regulation is immediately turned over to the municipal officials free to impose restrictions. Several examples exist where municipalities have installed unrealistic traffic control devices on major roadway improvements.

In one instance, a one mile section of a narrow two-lane roadway, carrying more than 30,000 vehicles a day, was widened to accommodate four lanes of vehicular traffic. This improvement cost in excess of one-half million dollars. A small municipality has a Four-Way Stop in place near one end of this major improvement. It is estimated the annual economic loss to motorists at this one intersection is in excess of $70,000 a year.

At one location, in addition to the traffic signal installation, at the motorist's near right, five traffic signs are located within a distance of less than thirty feet. These signs read in order:

No Parking Here to Signal
Stop at White Line on Red Light
Right Turn Only on Arrow
Danger Traffic Merging from Right
Stop When Signal is Off.

We all recognize that no motorist has time or distance in which to react to this conglomeration of messages. Each may have some degree of importance but how would the average driver recognize which to read first? It has often been said that no one should drive alone in the St. Louis Metropolitan area. For every driver a navigator is needed to read and interpret the variance of signs, signals and pavement markings encountered all along the way.

HOPE FOR THE FUTURE

The St. Louis County Division of Traffic activities are closely co-ordinated with the county highway department and planning commission. The planning department has the basic responsibility relating to proper land use in the unincorporated area and are involved in the planning of all highway improvements. The highway department is responsible for the actual design, construction and maintenance of these roadways while the division of traffic is responsible for all traffic regulations and controls. The close cooperation of these three groups, planning, highway and traffic with the ninety-eight municipalities are the essential elements in development of a successful long range master traffic plan.

As it is now, thousands of good, conscientious drivers are unknowingly violating the traffic regulations in their own and other municipalities because these regulations are obsolete, confusing, unrealistic, unreasonable, and unenforceable. The success of our program of increasing the degree of uniformity in traffic regulations and control devices presently hinges entirely upon its acceptance by the ninety-eight municipalities. To ensure this approval the St. Louis County Division of Traffic must develop specifications that are not only standard and uniform, but much more important, desirable and workable.

While most municipalities are aware of the standards in the Uniform Manual on Traffic Control Devices, they are not bound by these recommendations. St. Louis County is one of the strongest home rule counties in the nation and the state highway department and county government have no authority within the corporate limits of the ninety-eight municipalities. However, the outlook for uniformity in traffic control devices within the St. Louis Metropolitan area is good. For the first time in our area history, signs are beginning to pop up in the four corners of the county which look and are alike.

The encouraging response to the uniform street name sign program leads us to believe the first big step has been taken toward uniformity of all traffic control devices. The St. Louis County Division of Traffic will maintain a concentrated effort to obtain more uniform traffic control regulations. The co-operative type of approach is obviously the long and tedious method of alleviating our critical traffic conditions. However, we are willing to try until the proper legal authority is granted to regulate and control traffic on all major traffic arteries without regard for the boundaries of the ninety-eight cities, towns, and villages.

Greater uniformity of traffic control devices, in our opinion, is the least that our motoring public can expect from its traffic officials. Our entire roadway system is judged to a large degree by the signs our daily users encounter. It behooves us to strive to make the "signs of life" as meaningful as possible.

Virginia State Police Achievements in Traffic-Law Enforcement

COL. CHARLES W. WOODSON, JR.

Colonel Woodson is Superintendent of the Virginia Department of State Police. He joined the Department as a trooper in 1932 and has held the ranks of sergeant, lieutenant, captain, and colonel. In 1940, he was appointed Executive Officer of State Police; in 1942, the Governor of Virginia appointed him Superintendent. When the Governor's Highway Safety Committee was formed in 1946, Colonel Woodson became a member, and now holds the position of Chairman. He is president of the International Association of Chiefs of Police, past president of the Virginia Association of Chiefs of Police, a member of the FBI National Academy Associates, and of the Harvard Associates in Police Science. He has served in many capacities in national and international associations in his field. In 1956, Colonel Woodson toured police installations in England and Germany under the auspices of the Francis G. Lee Foundation. He has served as Superintendent under five Virginia governors.

CONTRARY to general belief, state police organizations are of relatively long standing and were not engendered by the emergence of the automobile into widespread use.

The germ of the present state police was in the Texas Rangers, recruited in 1835 as a border patrol. They were followed, in 1873, by the Royal Northwest (now Royal Canadian) Mounted Police who brought law and order to opening territories.

Although several organizations approximating embryonic state police appeared earlier, the first authentic state police department appeared in Pennsylvania in 1905. Its purpose was to provide an executive arm for the state, assist in handling disturbed conditions in the coal fields, and provide protection in rural areas that were without adequate law enforcement agencies.

The rapid rise of rural crime and the universal employment of the motor vehicle—with the part it plays in crime and the shrinking of jurisdictions brought about by its use—led to the development of similar organizations in other states. Some counties, appreciating

the situation, organized police departments along the lines of miniature state police agencies.

The Virginia State Police had its inception in the appointment of eight "inspectors" who were assigned to the Secretary of the Commonwealth and who were later absorbed by the Division of Motor Vehicles when it was established in 1924. These men, without uniforms, were largely concerned with license plates, titles and stolen vehicles, although they were endowed with a vague type of police authority. Because of the condition of existing dirt roads, the inspectors worked largely as clerks during the winter months.

Largely augmented in 1932, the group was reorganized and its members given general police powers, unrestricted as to jurisdiction within Virginia. Elementary entrance requirements appeared, a type of military organization was inaugurated, and the first basic training school convened.

In 1942, the Department was separated from the Division of Motor Vehicles and became a state agency in its own right, with the Superintendent responsible only to the Governor.

When I joined the Department in 1932, we were in the depths of an economic depression. I applied when twenty-five new positions were created and the first basic training school was announced. There were some 5,000 applications for a position which was to pay $85 per month and from which there would be an almost irreducible minimum of free time.

One hundred applicants were selected from the 5,000 and these went to training camp, with no salary and with the knowledge that only twenty-five would survive. Still unpaid, the twenty-five selected waited three months for the jobs to be established.

BEGINNINGS OF POLICE AGENCIES

We, of course, see some public resentment directed against the police today, but this generally arises from improper or misguided actions on the part of individuals or individual departments. In the beginning, police agencies came hard to the English people, who stood in dread of the high-handed, autocratic methods of the huge, semi-military continental organizations. Until as late as 1749, the vast metropolis of London was utterly without any organized police department.

In rural areas, village constables could enlist the aid of the people; but in the cities, apart from aged watchmen, there were only individuals known as "thief takers" who received bounties for apprehending criminals, but who had no official standing whatsoever.

The need for police protection finally gave rise to an organized police department known as the "Bow Street Runners," from their headquarters in London's Bow Street. At first, this organization met with bitter public enmity and animosity, but continued to grow in stature and became the Metropolitan Police Department of London as it is today.

Their success was based upon the firm indoctrination that they were public servants, that their own lives must be above reproach, and that their business was the prevention of crime.

Most state police departments sprang from small cells attached to motor vehicle divisions, highway departments and other state agencies, and all have either become entities or have increased vastly in size and importance with the ever-increasing use of the motor vehicle.

PROBLEMS OF TRAFFIC-LAW ENFORCEMENT

One of the problems of state policing is whether to insist that duties be confined to the highways only, or to permit work in other fields of law enforcement. In our department, the feeling is that while a state police officer belongs primarily on the highway, he cannot, as an officer of the law, ignore other types of offenses. To do so, we believe, would cause him to lose stature in the eyes of the public he serves. In this connection, I speak for Virginia with its large rural areas and the problem of twenty-four-hour coverage.

However, the basic problem in traffic-law enforcement and, indeed, in the whole tragedy of our traffic slaughter lies in the attitude of the people. So swiftly has the impact of the automobile struck us that, in my opinion, we simply have not evolved a proper code of ethics for its use; nor have we come to appreciate the motor vehicle—originally but a pleasure and convenience—as the dangerous instrument it now is.

Generally speaking, the mass of the people does not look upon a traffic-law violation as a ciminal act or as anti-social conduct.

For example, a conviction for drunken driving brings nothing like the social censure that accompanies one for simple public drunkenness. This attitude is often reflected in jury and witness action.

There is also a strange reaction toward law enforcement officers charged with traffic duties, that likens enforcement to a type of game in which a violator should have an "even break." One arrested on a speeding charge will cry out that he is the victim of a "speed trap" or that he was justified by existing conditions in exceeding the legal limit. Officers are accused of having quotas to fill, of being in league with justices of the peace in raising funds for various localities, and of having financial interests in fines assessed or in forfeited bail. Here it should be noted that our troopers are paid straight salaries and have no quotas to fill and that money from fines and bail is paid into our school fund.

These attitudes, I believe, have origin in public sentiment against lawbreakers some sixty years ago. Then, our society was sharply divided into two parts—the large percentage which obeyed laws and the relatively small criminal element which did not.

The criminal section was beyond the pale of social condonation. Today, however, everyone drives and everyone at times breaks traffic laws. Thus the famous "But for the grace of God, there go I" attitude so prevalent among jurors is adapted to the whole situation.

TRAFFIC PROBLEMS IN VIRGINIA

Beside the basic problem of human indifference to traffic dangers and the feeling that breaking traffic laws is not a criminal act, Virginia has problems that are shared with more or less intensity everywhere.

As a "bridge" state on the Eastern Seaboard and one that attracts a large number of visitors, Virginia has many non-resident violators. Unfortunately, some of these feel that hospitality should extend to undue tolerance where our speed limits are concerned.

Another handicap for visitors is that our laws do not permit justices of the peace to try cases, thus necessitating the bonding of non-residents for their further appearance before the court having jurisdiction. Extradition would be prohibitively impractical where a traffic offense is concerned so the non-resident necessarily faces the inconvenience of awaiting trial or returning.

A terrible problem of today, which appears to loom larger and larger each year, is that of the drinking driver. During 1958, one of these offenders was known to have been involved in 33.3 percent of our fatal crashes and it is certainly reasonable to presume that this percentage would be considerably larger were all facts known in all cases.

We have striven to impress upon public thinking that alcoholic effects that might pass unnoticed at a social event can be lethal where driving an automobile is concerned. People must be made to realize also that one of the insidious properties of alcohol is the impairment of judgment and that a driver who felt it was safe to drive at the time might well shudder in horror at what he had done when alcoholic effects were gone.

For many years, Virginia has had a mandatory one-year license suspension for the first conviction of drunken driving and, more recently, chemical test legislation. Yet in spite of all that has been done, the problem appears to be worsening.

Radar and unmarked police cars, while vital aids to traffic-law enforcement, engender public resentment on the grounds that they are "unfair." Radar devices are used at any point along our highway system, but at the outskirts of each city and town large signs point out this fact. Along the highways other signs indicate our top speed limits. Thus no one but a violator need fear radar, and there is no basis for the "entrapment" plea since drivers are in no way lured into committing an offense.

In our opinion, both marked and unmarked patrol cars have definite places in enforcement. The marked car is a deterrent to the inattentive driver who might break a law, but the unmarked car is necessary for those who desire to break laws and who are eternally on the lookout for a patrol car. The use of unmarked cars also brings the unfair plea, but a motorist prone to violate is less likely to do so when he does not know when or where he is going to encounter a trooper.

A series of tragedies, in which drivers fleeing police have struck and killed people in the way, has focused national attention on the high-speed police chase, and aroused some public feeling which questions the wisdom of police pursuit.

However, the first duty of a police officer is to put a halt to the

existing violation before damage is done. Then we must consider what could happen were officers forbidden to pursue a violator who refuses to halt upon signal. Violators, secure in the knowledge that pursuit had been forbidden, would simply accelerate their vehicles when an officer signaled them to stop. Thus the officer would be helpless.

The argument has been advanced that the officer could take the license number of the vehicle and arrest the driver later. However, difficulties present themselves here. The dangerous violation is not immediately halted; checking the license and apprehending the driver would be a lengthy process; the license number gives access to the owner but not necessarily the driver, and drivers of stolen cars could not be apprehended. Also, questioning a driver in violation often reveals other violations.

IMPROVED POLICE METHODS

Most of the scientific improvements in police equipment have come in the field of communications. When I first took the road as a trooper, a vast territory was assigned to me and there were no car-to-car or car-to-headquarters radios. Arrangements were often made with various businesses along the individual trooper's most traveled route whereby a flag was raised upon receipt of a call for the trooper. When the trooper noted the flag, he entered and returned the call. This is a far cry from two-way radios, microwave, and portable teletype.

Other advancements include chemical tests for intoxication, moulage, infra-red photography, radar, electronic speed-timers, and fingerprinting developments. Yet, in the final analysis, the greatest asset to police work at this date appears to be the young men of integrity and ability who join our ranks.

All work and all use of equipment must rest squarely upon the individual man. And this man must keep pace with not only those of warped intelligence who turn to crime and also use scientific aids, but also with the inadvertent breaker of a traffic law who has never before experienced arrest or court action.

I believe police administrators have achieved some success in the selection, training, and retraining of personnel. However, much work needs to be done in the field of training men for supervisory

positions as well as those now in supervisory positions. We might not make psychologists of corporals, sergeants, lieutenants, and captains but we can solve many problems in human relations if we give supervisors the benefit of experience that has been garnered with difficulty through the years.

As time passes, we continue to progress steadily in raising the standards, procedures, and ethics of the police profession. The old attitude that "anyone can be a policeman" is passing, as the highly finished product of modern police departments meets the public.

ALCOHOL AND ENFORCEMENT DILEMMAS

We cannot here attempt a discussion as to the moral aspects of the use of beverage alcohol. At the same time, we cannot evade the inescapable fact that large sections of our population use it and think they are commiting no wrong in so doing, as long as they violate no laws, or otherwise misbehave.

Very much the same thinking existed at the time of national prohibition and thus the police suffered a decided setback. Officers were ordered to enforce laws which many people thought interfered with their inherent personal rights.

As with the advent of general use of the automobile, respectable citizens became arrant lawbreakers and no stigma was attached by many to the breaking of prohibition laws. Side by side with thousands of citizens who dealt individually with bootleggers, rose syndicates and gangs of the worst criminals in our history.

Unfortunately, police salaries were inadequate and the temptation of heavy inducements to look the other way proved too much for some officers. Add to this the fact that much of the public vented its spleen on the police for attempting to enforce laws deemed by many to be unpopular, and it is not hard to see why we lost ground.

TRAFFIC SAFETY SOLUTION IN EDUCATION

Often we are asked what the solution will be to the traffic safety problem. In my opinion, it lies in the field of public safety education and in the education of youth within the schools, seconded by parental control and exemplary guidance.

While police action is very necessary to the control picture, the public is too prone to feel enforcement is the only approach. Let

there be a sudden rash of fatalities and the complaint is voiced that the police should be doing something. No similar cry is directed against engineers or educators.

In blaming the police, the public often fails to realize that enforcement does not consist of police action alone. Enforcement also requires adequate laws and effective court action, neither of which can be achieved without popular approval.

The police cannot force the traffic millenium upon the mass of the populace. Were our ranks tripled, we could not hope to reach but an infinitesimal portion of those who daily violate our traffic laws.

When we turn to highway engineering, it is obvious that many improvements built into our roads to render driving more pleasant and more convenient paradoxically invite excessive speed.

It is difficult to believe that any vast improvement can be gained until the people look upon improper driving as they look upon other forms of lawbreaking. It is indeed strange that indifference persists in the light of a recent national survey (conducted by the Kemper Insurance Company of Chicago) which revealed that seven of ten people killed or injured in traffic suffered at the hands of drivers violating traffic laws. The "it can't happen to me" philosophy is indeed well rooted!

We endeavor constantly to impress upon Virginia troopers that the most effective attitude with which to meet the violator is one of firmness, intelligence and civility—a manner that tends to make the wrongdoer feel ashamed of himself rather than resentful. Too often in the past, uncouth officers with the "Where's the fire?" approach have damaged good public relations that have been built so slowly.

While we empower a trooper to administer a verbal warning in a borderline or not-too-serious violation, we do not use written warnings that can become part of the individual driver's record.

Police officers, as human beings, are capable of making errors; courts and jurors sometimes do not agree with them. Consequently, in our judgment, it is impractical to participate in the placing of a mark on a driver's record when the driver does not have his day in court.

In the enforcement field, Virginia officers have found that license suspension is the corrective measure most feared by drivers. In ad-

dition to the one-year mandatory suspension for conviction of driving while intoxicated, we have long had one of six months for two offenses of reckless driving within any twelve-month period. Recently, the Department added a mandatory sixty-day suspension for two speeding convictions occurring within twelve months, or for a conviction of speeding and one for reckless driving. Apart from mandatory provisions, judges are given very broad discretionary powers as to lifting licenses.

It must be said, at least for Virginia, that the public appears to be more and more concerned with the problem and proportionately more willing to accept sterner control measures. While progress might be slow, it is definitely there. Those of us in the enforcement field must ever work to keep this flame alive, to render the most efficient service possible, consistent with the tax dollar, and to keep ourselves above reproach.

To achieve these ends means keeping abreast of every modern aid and measure accorded to law enforcement. We must ourselves seek constantly to improve our methods and procedures. We must endeavor to build the reputation of public respect, efficiency and outstanding, impartial service that will continue to attract young men of the highest caliber to our ranks.

Gasoline Taxes and the Small Car

JAMES S. BURCH

Mr. Burch has been Planning Engineer for the North Carolina State Highway Commission for the last twenty-two years. He handles highway planning surveys, research projects, needs studies, planning and programming, mapping and traffic studies. He has had thirty-five years of experience in highway and traffic engineering. He has made traffic planning studies of forty-two North Carolina cities. He is a member of the American Society of Civil Engineers, of the North Carolina Society of Engineers, of the National Highway Research Board, and of the Institute of Traffic Engineers.

FOR nearly forty years, revenue from gasoline gallon taxes has been the basic financial support for all state highway operations. This has also been true in recent years for federal highway aid. In many states, cities and counties share directly in state gasoline tax revenue through state aid for street and local road purposes.

As the tax rate per gallon has been increased by the federal government and by many of the states in recent years, this revenue has become more important in financing construction and maintenance of all traffic facilities.

Consequently, the reduced per-mile gasoline consumption of the small car, while advantageous to the car owner, is of serious concern to highway, road, and street officials all across the nation. They ask, "What effect will these small cars have on the revenue-income needed for our highway, road, and street work?" Obviously, the answer will best be found in the relative number and use of small cars.

In early 1959, the writer canvassed pertinent research literature but was unable to find any reliable data on the prevalence of the small car in the composite traffic stream, or on the extent of small-car total travel. To obtain such data, it was arranged that all regular North Carolina State Highway Commission traffic-count men make separate tallies on small cars in connection with their regular counting schedules for the entire month of April 1959, in all areas of the state.

The result of this first study, reported in the July 1959 issue of

American Highways, revealed the following figures and estimates:

Eight-hour observations at each of 857 highway-road segments in rural areas of fifty-eight counties showed that 2.63 percent of the 658,000 passing passenger cars were small cars. The computed theoretical gasoline tax revenue loss was only about eight-tenths of one percent, attributable to the reduced gasoline consumption of the small car. A similar study was announced for the fall of 1959 to determine the trend.

Accordingly, and in a similar way, eight-hour traffic counts were made manually in October 1959 on 773 scattered rural highway-road segments in sixty-three different North Carolina counties. Of the 728,400 passing vehicles, including 545,694 passenger cars, 17,693 or 3.24 percent were small cars.

The following table compares the percentage of small cars to all passenger cars as observed in the April and October counts.

TABLE I—PERCENTAGE OF "SMALL" CARS OF ALL PASSENGER CARS

(Upper figures for April 1959, lower for October 1959)

	Part of State			
Rural System	*East*	*Central*	*West*	*Total*
Primary highways (includes Interstate)	2.58 3.52	3.08 3.10	2.28 3.26	2.72 3.34
Paved local roads	1.89 2.70	3.33 2.57	1.50 1.62	2.48 2.32
Unpaved local roads	.045 0.54	1.10 0.50	1.26 1.02	0.88 0.60
All	2.52 3.45	3.10 3.06	2.22 3.10	2.63 3.24

As compared to the April 1959 data in rural areas, there was a significant October increase in the small car percentage on primary (and interstate) highways, especially in the eastern and western thirds of the state. Little consistent change is noted in other areas or on other systems.

In October, the indicated theoretical gasoline tax revenue loss, due to these small cars, is in the order of 1.0 percent as compared to the revenue from equivalent travel by conventional cars. Some of

this indicated loss may be offset by increased travel associated with the purchase and use of the small car. The recent general growth trend in total gasoline consumption by all vehicles in North Carolina has been so strong that the effect of any actual loss due to the small car cannot yet be isolated.

None of the data in this report includes the effects of the new "compact" American-made cars introduced into the market in October 1959. Such cars in operation were so few in number as to have no significance in the composite state-wide traffic stream.

Because of the prolonged 1959 nation-wide steel strike and its adverse effect on the production of American cars, the sale of foreign-made small cars in the United States may increase significantly during the winter of 1959–60. (This report is being written in November 1959.) The effect of this increased sale of foreign small cars, and the ultimate impact of the compact American car cannot likely be appraised in terms of actual gasoline tax revenue loss before the summer of 1960.

In all sections of the state, the percentage of small cars to all passenger cars remains very similar throughout the three parts of the twenty-four-hour day, indicating that the use of small cars by trip purposes is generally the same as that for conventional cars. This observation results from an analysis by hour periods within sections of the state.

The rural observations made during April 1959 are exactly corroborated by similar counts inside the City of Charlotte, North Carolina, in August 1959. This unpublished city data comprised twelve-hour observations on each of twenty-five scattered streets where an aggregate total of 305,337 passing passenger cars was classified. It was found that 2.66 percent of these passenger cars were small cars.

These data, furnished by the city traffic engineer, were almost identical with the state-wide April percentage of 2.63 shown for rural areas. This would indicate that the prevalence of the small car is as great inside as outside cities, at least in North Carolina.

OTHER SMALL-CAR CONSIDERATIONS

In addition to the revenue effect, extensive use of the small car will tend to cut down the efficiency of traffic operation in terms of

highway traffic capacity, because of the driver's low eye-height and corresponding short sight-distance. The same effect would be felt because of the small car's low horse-power and inability to climb hills or to accelerate and complete an overtaking passing maneuver in a short highway distance. These factors produce somewhat the same capacity-effect as a large, heavily-laden truck.

Furthermore, the small car is difficult to see when it is at the bottom of a vertical curve, and this fact may introduce special traffic hazards. In case of collision or turn-over, the small car may exhibit lower structural resistance, thus adding to the seriousness of an accident involving such a car. These observations are not covered by the study data and are merely opinions of the writer.

One of the basic troubles that plague the designer and make highway-street planning more difficult is the wide variety of vehicles and purposes to be served. What level of service is to be provided?

We have the high-speed passenger car moving straight ahead and demanding clear right-of-way. The slow car-driver clogs the stream and creates further turbulence in his left and right turns. The large heavily-laden truck cannot pull even minor grades, it accelerates slowly, requires wide turning room and storage space, and blocks the view ahead. The same is true for the towed house-trailer.

Any vehicle entering from right or left creates extreme turbulence in the traffic stream and is a special hazard. Any vehicle may become a breakdown obstacle because of malfunction, tire trouble, or lack of fuel. Such a stop, or the stopping of a bus, will quickly clog a traffic lane for a thousand feet back.

The pedestrian is perhaps the most difficult element of all because of his slow walking speed and drivers' difficulty in seeing him amid large vehicles, especially at night. Children are most unpredictable in their movements.

Now, to this complex situation is being added the small and the medium car, with additional new size and horsepower characteristics. All these factors must be evaluated independently and in combination, and then projected some twenty years into the future to allow for traffic growth.

These problems—seldom considered by the usual driver—become so complicated that they often defy solution, making it impos-

sible to provide fully desirable facilities for every class and purpose. The highway-street, as a public utility, therefore, is usually much less efficient than other facilities or machines designed and used for single purposes under strict control.

At this writing, no one can predict the extent of use of the small and the compact car in the years to come. Within 1959 alone, we have witnessed three major changes in the passenger car situation: The up-surge of foreign small car sales in the United States; the prolonged steel strike, limiting all American car production, and the introduction of American-made compact cars. All of these developments are without precedent, and their resultant effect on gasoline tax revenue over a long period cannot yet be evaluated. The ultimate determination, of course, will be the decision of the car-buying public.

Newark Plans Dynamic Changes For Its Downtown Center

HENRY W. CONNOR

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THE planning of redevelopment in downtown Newark can be understood only against the background of dramatic civic and political events that directed the city's economy away from depressing deterioration toward dynamic development.

This striking change is not unique to Newark. All over the country, central cities are awakening to the possibility of renewing their economies. However, the break with the past has come more rapidly in Newark, and some of the elements behind the rebirth have been developed to a greater degree than in other large cities.

Fortunately, those of us who have worked on the programs can rely on the word of an objective observer about what has happened.[1]

> . . . There is a new life in Newark, a new sense of destiny. It can be seen in the new towering metropolitan skyline, modernized factories, new and spruced-up housing, a stunning new medical center, a new downtown combined YMCA and YWCA building, well-kept parks, clean streets with rushing cars, buses and trucks, and the terrific ebb and flow of commuters.
>
> Two great assets of Newark are location and transportation. On the first firm, flat ground west of the New Jersey tidal swamps, the city sits astride five of the nation's major freight and commuter railroads, is fringed

1. Luther Gulick, President of the Institute of Public Administration and former City Administrator of the City of New York, described Newark's renaissance in a recent article, "Operation Bootstrap," in the National Civic Review.

by a network of new thruways—the truckers' delight—and boasts a busy national airport and growing ocean port with modern docks, low-cost loading equipment, integrated warehouses, and rail and truck facilities. Both ports are managed by the Port of New York Authority on long term leases. Anyone who has been abroad will recognize that the Newark docks follow the deep pattern and direct transport connection scheme of the new Hamburg docks, reputedly the most efficient for general cargo.

Newark has the great advantage of being an integral part of the tri-state New York metropolitan area and is as near in time to the throbbing Manhattan center as are many parts of Brooklyn, the Bronx, Queens, and Yonkers. And like all of these, the economic life of Newark rises and falls with that of the entire metropolis; and any manufacturer or businessman can keep in touch with each change in world demand, or draw on the full gamut of 'external economies' from the entire region—and in turn make his contribution to this productive center.

CHANGE IN GOVERNMENT SIGNIFICANT

Significant in the series of events that produced this favorable climate in Newark was the agreement of some forward-looking business, labor, and government leaders to work for an improved city government in 1952. This action was followed by the adoption of a businesslike mayor-administrator city charter in 1953 and the election of a competent administration in 1954. This new administration made urban renewal in all its phases the heart of the city's program.

Citizen participation and support became a regular feature of Newark's new program. A new civic organization, the Greater Newark Development Council, was organized by the business community to provide policy decision by business leadership in the rebuilding of the city. Under this Council, the Bureau of Municipal Research develops programs; and the Newark Economic Development Committee, staffed by the Greater Newark Development Council but appointed by the mayor, activates these programs.

These political and civic developments and the improved climate generated by them led Mutual Benefit and Prudential Life Insurance Companies to rebuild their home offices in downtown Newark, instead of in the suburbs where they had previously acquired land. Among other significant construction projects have been Newark Airport and Seaport. The scope of this development

can be appreciated from the announcement in April 1958 of construction of a $232,000,000 second channel in Port Newark.

The total private and public projects planned, underway, or completed in the last five years, total more than one billion dollars, equivalent to one half the total value of all Newark private and public realty property in 1953.

These things were made possible through a firm partnership of government, labor and business that found in this program of economic development and urban renewal, wide areas of identity of interest.

DOWNTOWN STUDY MOST IMPORTANT

The recent study of the Newark downtown area is a good example of how this partnership functions. Like most cities, Newark has been uncomfortably aware of the growing traffic problem that has been increasing since World War II. Congestion, delays, and economic deterioration had brought some responsive action under the city's inefficient Commission government. Newark had its share of one-way streets, short-lived enforcement drives, and even a major street widening on Bloomfield Avenue (a major east-west artery) in 1953. It is fortunate in having excellent rail commuting service provided by the Pennsylvania, Lackawanna, Erie, and Jersey Central Railroads, all of which serve Newark as well as Manhattan.

Newark is the funnel through which traffic flows from suburban New Jersey to New York. For public transportation, it also has the excellent Public Service Co-ordinated Transport bus system, one of the largest in the world, with 6,600 buses serving downtown Newark every day.

The city's approach to the growing transportation problems was intermittent and haphazard. The inadequately staffed traffic engineer could do little but meet emergency problems. There was no permanent professional planning staff.

Under the new government, an intelligent approach to transportation evolved. Today civic and governmental staffs work together to develop and carry out planning and construction projects.

In the recent central business district study, the semi-official sub-committee of the Newark Economic Development Committee, staffed by the Bureau of Municipal Research and the city planning

officer, recognized the need for an overall concept as a guide to the development of Newark's downtown area.

NEED FOR ADDITIONAL STUDY

Construction of new office buildings was already underway. A redevelopment project had been started at one end of the area, and others were being considered. The parking authority, with the help of the city traffic engineer and the Bureau of Municipal Research, was about ready to take bids on the city's first underground garage in Military Park. The state highway department was proposing two east-west freeways through Newark, neither of which, however, provided adequate access to the central business district. In addition, a state rapid transit study that paid scant attention to Newark's needs had just been completed and was being quietly buried.

The city, with its newly created planning staff, was well along in an urban renewal demonstration project to develop a ten-year renewal program for the neighborhoods of the city. Thus it was possible at the same time to initiate an intensive central business district study that would supplement the city-wide study.

The approach was unique. Many central business district studies have been undertaken by city planning staffs or outside consultants. Newark needed a quick study to remain ahead of rapidly developing construction projects. It desired the very best talent available. The Newark Economic Development Committee together with the mayor and the planning officer recommended the employment of a team of consultants including a prominent architect and planner, a shopping center specialist, a transportation specialist, a market analyst, and an additional planner.

The study was not to be the traditional master plan, not a detailed project plan nor a promotion piece, and not a prediction of future developments for the central city.

Instead, it was designed to produce an overall concept of the best land uses in the central business district, based on an integration of economic, transportation, architectural, and planning considerations. It was designed to bring together the best available experts in these various fields, and to cross-fertilize their ideas with those of Newark's community leaders to obtain practical concepts, custom-tailored for Newark.

The result, "Newark, New Jersey, a study of the Downtown Area," met our objectives. The concept is based on broad national and local knowledge of the forces at work in the downtown section, adequate research to project future potential of the area, and an integrated transportation system to serve the needs of both present and future.

POTENTIAL FOR 'NEW NEWARK'

The consultants reported, on the basis of the economic part of the study, that the city and its central business district have a singular opportunity for dynamic growth over the next twenty years. It was emphasized that these findings relate to a potential and do not necessarily represent a prediction or forecast. By potential is meant economic conditions that may be brought about, if suggestions in the study are implemented.

Newark has a daytime population twice that of its full-time residents. Into the 700-acre study area more than 122,000 workers commute daily. Broad Street, the main north-south street, is the heaviest bus-traffic street in the country.

The study showed that by 1975, population for the surrounding area will increase by forty percent and Newark will be the central city in this increasing ring around Metropolitan North Jersey.

NEW CBD DEFINED

Of prime importance toward implementing the potential outlined, is an improved transportation system that will involve freeway and major arterial street development to provide direct express service to the central area; and a freeway loop system around the central business district so that traffic not destined to the central core will be routed around it.

Necessary steps were outlined to improve the quantity and quality of the city's public transportation. Of great importance to future growth was the development of a balance between private automobile traffic—for which existing parking structures must be supplemented by additional facilities—and public transportation.

One objective of the study was to define the central business district. Assigned to the consultants for survey was a 700-acre area along Broad Street, with mixed business, industrial, and residential

uses. It was recognized that this area was too large for intensive business development in a city the size of Newark. The consultants recommended that the term, central business district, be used only for the core of this area, some 170 acres in the heart of the study location.

This prime area is actually the business heart of the city. Immediately surrounding this central business district is the "belt" area.

Some challenging developments were suggested for these two areas. Within the 170 acres of the central business district, eighteen acres are proposed for the most intensive business activity and services. Other uses, for hotels and home-office space, will total fifty acres. The city's major retail stores will require about twenty-nine acres, and present and proposed government structures will occupy twelve acres. The central business district will include both Washington and Military Parks (about thirty acres), and mixed residential and commercial areas will comprise twenty acres. Remaining acreage will be used for parking facilities.

Suggested uses for the belt area of 530 acres make an interesting comparison with the central business district figures. The mixed residential and commercial area within the belt occupies 113 acres; an additional 112 acres will be set aside for a strictly residential area. The institutions, new college campuses, hospitals, and cultural area will require sixty-six acres. Eighty-four acres of parking would be well situated throughout the belt, with easy access to the central business district. Parks and walkways would take up about twenty acres, and the remaining 134 would be reserved for industrial use.

PROJECTED ESTIMATES FOR NEWARK AREA

The Newark Metropolitan Area, containing some 2,180,000 people, is the area in which Newark's influence is greater than that of Manhattan. By 1975, the population of the five counties of Essex, Union, Morris, Somerset and Middlesex, plus parts of Bergen, Passaic, and Hudson Counties is expected to grow by forty percent to about 3,060,000. Its present employment of 800,000 is expected to increase by seventy-four percent to about 1,390,000 workers in the same period.

Against this background of metropolitan growth, the 1957

estimated population of the City of Newark was 451,000. The proportion of metropolitan growth that will take place within the city boundaries depends upon the urban renewal policies and programs in Newark.

Redefining of the central business district, with projections for office, industrial, residential, commercial, and parking areas, is a much-needed step to meet the challenge of the sixties. Developing the central business district, the belt, and the traffic pattern within the framework of urban renewal can be completed only with the co-operation of all groups.

To service this metropolitan area, the Newark central business district will require a substantial increase in business building.

As projected, there will be some reshuffling of existing uses. Industrial uses in the central business district are expected to decline substantially. The projection for office, bank, and hotel floor space is an increase from eleven and a half million square feet to seventeen and a half million square feet by 1975.

In the belt, a small increase in office space is projected, with a substantial increase from eight to ten million square feet in industrial space.

It is recommended that retail space be centered in the central business district with an increase of 750,000 square feet. Some of this will be shifted from the belt area where a decrease of 400,000 square feet is expected.

Employment in the central business district would increase from 95,000 to 116,000 by 1975. A 5,000-increase in the belt area is also projected.

NEW DIMENSION TO URBAN LIVING

New high-rise residential areas are recommended for the belt and surrounding region, integrated into the central portion of the city. This plan would provide a new dimension to urban living. Where people in recent years had no choice but to move to the suburbs, the new downtown residential facilities proposed would win back many friends of city living.

In addition to its commercial, business, and housing functions, the central business district and adjoining areas will assume a new role through development of cultural and educational institutions.

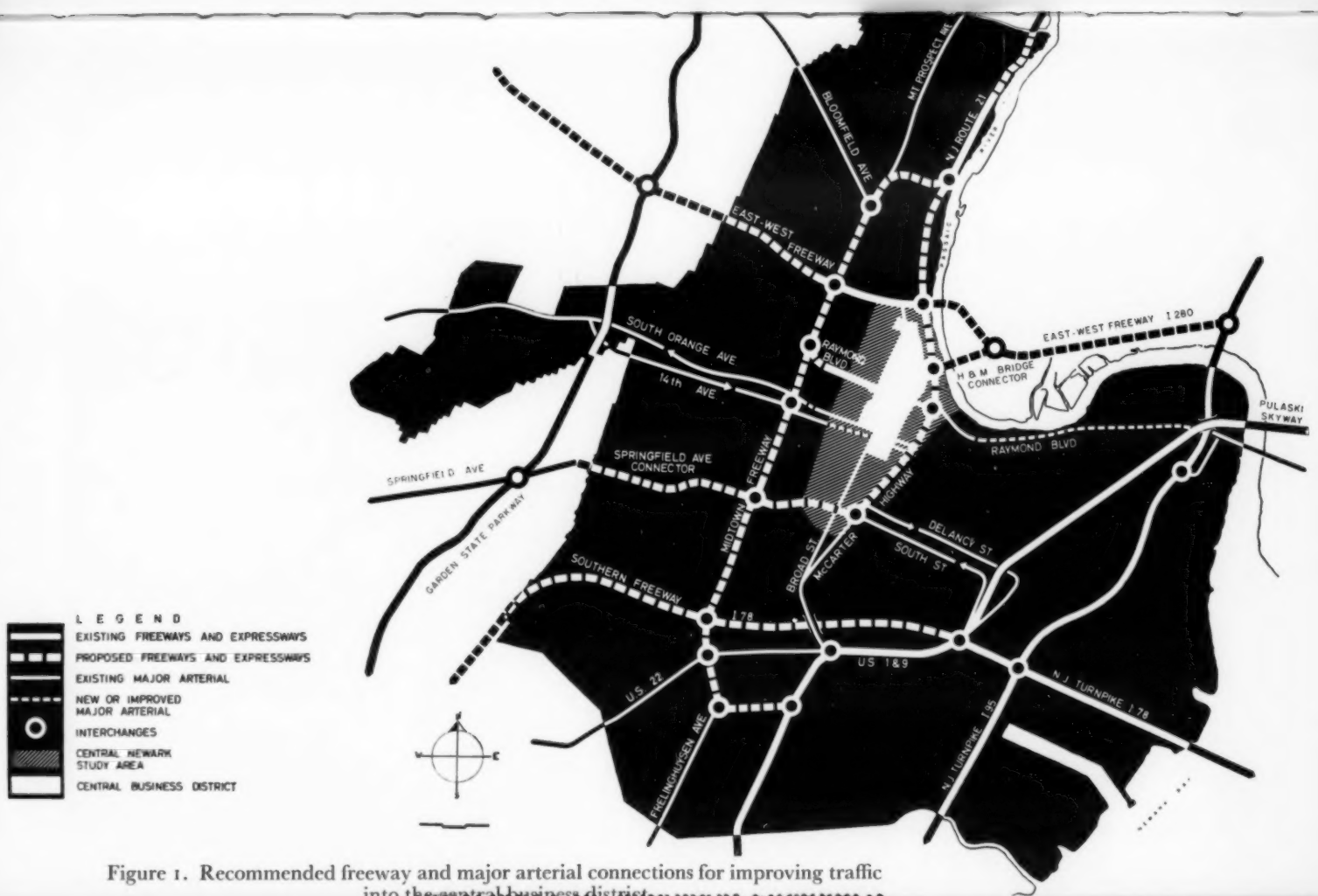

Figure 1. Recommended freeway and major arterial connections for improving traffic into the central business district.

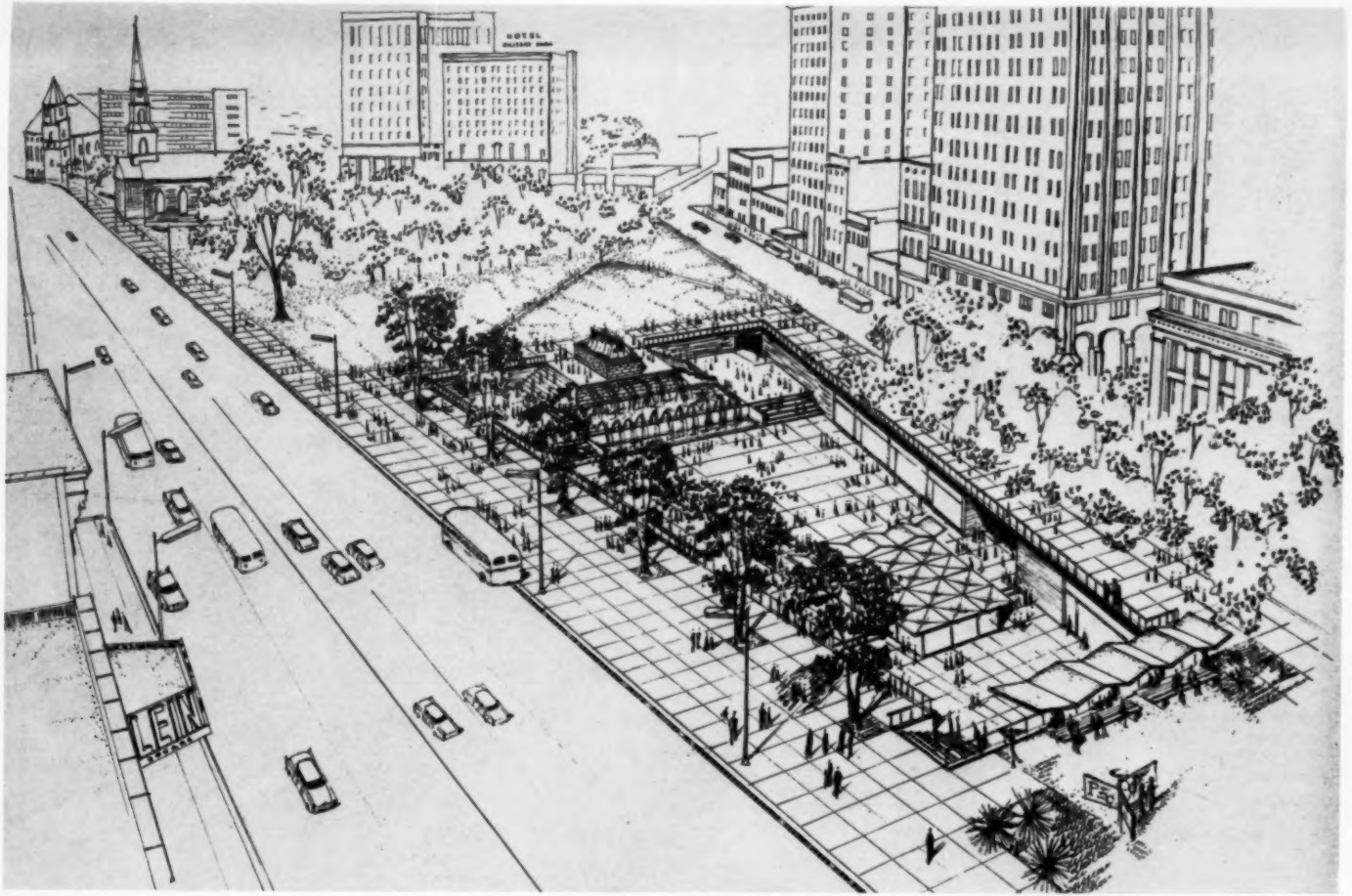

Figure 2. "The Hub" of Newark could become a major attraction to shoppers and business interests throughout the Newark Metropolitan Area.

These include plans for a Seton Hall University campus in the Newark Plaza Area, expansion of Rutgers University and the Newark College of Engineering in conjunction with other cultural activities, and new hospitals in the cultural unit west of Washington Park.

A government center is planned for the site around city hall. A light industrial park is suggested to the south-east of the central district, and a light industry park to the south-west.

The consultants point out that while exact borderlines of certain land-use areas and exact alignments of freeways or highways have not been established by this study, the recommendations contain principles essential for revitalizing downtown Newark.

The metropolitan area served by Newark includes 980 square miles in both the New York and Newark metropolitan areas and, as noted above, Newark has a more dominant position than Manhattan in its own region. This dual metropolitan role, considered by some as a detriment to Newark's growth, is in reality a prime factor for its future potential. As the central city for a major part of North Jersey, Newark will assume increasing status in performing metropolitan center services for its region.

FREEWAY AND MAJOR ARTERIAL SYSTEM

For the city to realize its potential, easier access to its central business district must be provided—particularly from the west where increased population is expected during the next twenty years.

The recommended freeway and major arterial system (Figure 1) indicates the freeways and arterial streets needed for these improvements. The Garden State Parkway and the New Jersey Turnpike, already in existence, form the western and eastern parts of an outer loop system.

The Southern Freeway, Interstate 78, and the east-west freeway, Interstate 280—to be constructed as part of the federal interstate system—will form southern and northern parts of the outer loop. Completion of this outer loop will enable long-distance through-traffic not destined for Newark to bypass the now congested city streets. Presently, this is one of Newark's major traffic problems.

Much of the traffic destined to the heart of the city will come in

on these freeways. But to distribute this traffic and permit easy access to and from the central business district, an inner loop system will be required. This would be provided by construction of the Springfield Avenue connector which will cut through the southern end of the study area, a midtown (north-south) freeway, and an improved McCarter Highway. The midtown freeway will have interchanges with the outer and inner loop system, as well as existing highways and major arterial streets, for easy dispersal of traffic to and from the central area.

A one-way street plan involving South Orange Avenue and 14th Avenue will provide easy access to and from the Garden State Parkway; and a one-way system on Delancy and South Streets will provide access from the central business district to the Airport interchange where existing Route 1 and the New Jersey Turnpike meet.

Another recommendation provides for a Hudson and Manhattan Bridge connector with the east-west freeway. This would make it possible for traffic from the east to reach the Military Park underground garage (now under construction in the central business district) without using city streets.

Further improvements were suggested to insure expressway access to the east and west sides of the central business district with more effective use of Raymond Boulevard. The consultants believe these highway-improvement needs are apparent now without a more elaborate highway planning study. They point out that new data and a more intensive traffic analysis may show the need for additional freeway and arterial improvements to serve downtown.

Traffic consultants find that in spite of growing private automobile traffic, public transportation by railroad, subway, long-distance and local buses plays a vital and essential role in the economic life of the central business district. A future study of transportation was recommended.

A parking analysis revealed that there are 16,800 public off-street parking spaces available and more than 21,000 parkers; that 4,500 curb spaces are available and 13,250 parkers use them daily. While a large amount of off-street parking does exist, most of these spaces are not well located for shoppers' parking. The need for centrally located parking facilities is being met in part by construction of the 1,000-space Military Park underground garage. It is

estimated that a thirty-five percent increase in parking spaces will be required to accomodate the city's normal growth.

Since the study was a prelude to action, the continued cooperation, education, understanding, and consent of the local government, business, labor and civic power structure was continuously emphasized.

PLANS FOR THE HUB

Broad Street is the busiest bus route in the world. The subway crosses Broad Street just south of Military Park and ties the public service bus terminal in with the Pennsylvania Railroad station to the east. The new underground garage will be under the north end of Military Park, close to where the proposed Hudson and Manhattan high-level bridge will connect with the east-west freeway.

The consultants recommend "the creation of a below-grade plaza at the southern end of Military Park from the War Memorial to the intersection of Broad Street and Raymond Boulevard, connecting on the low level the new Military Park garage to the city subway and bus subway. This development would tie together the intensive retail area west of the park and the intensive office spaces to the east, and enable people to walk from the Public Service building to the west side of Broad Street without crossing traffic.

"This open concourse, lined with stores and embellished with a fountain under Gutzon Borglum's 'Wars of America' Monument in Military Park, would form a practical, and at the same time, exciting new facility acting as the Hub of the new downtown." (Figure 2).

NEWARK PLAZA PROPOSALS

The recommendations and subsequent $95,000,000 proposal for the Newark Plaza afford an excellent example of tying together street and highway planning and urban renewal.

The Newark downtown area study recommended relocation of McCarter Highway eastward to the Passaic River and a further relocation of Mulberry Street to connect with Park Place and Central Avenue. These changes will improve traffic conditions and make available an area undisturbed by through-traffic, and large enough to create its own individual residential climate. A plaza

opposite the Pennsylvania Station (fifteen minutes from mid-town Manhattan) would provide a fitting and exciting entrance to the center of the business district between the commuter railroad and Broad Street.

Last October, a new proposal was submitted to the mayor and city council for acquisition and development of this area. The plan provides for 4,100 dwelling facilities in high-rise structures of fifteen to thirty stories, together with small stores, service, and recreation areas necessary for about 12,000 residents and 10,000 students of the new Seton Hall University, an integral part of the project.

Commercial facilities would be located predominantly along Mulberry Street. A twenty-story office building, with parking garage and first floor commercial space, is planned along the west side of Mulberry Street, bridging Clinton and Commerce Streets. This location is in the intensive business-services area proposed in the study.

OTHER RENEWAL PROJECTS

Other renewal projects affecting parts of downtown are underway. Voters last November approved a sixteen-million-dollar expansion of Rutgers University and Newark College of Engineering. The City Museum and several hospitals are developing plans that will round out a cultural and educational center in the belt area of the central business district west of Washington Park.

Three other proposals have been submitted: one for an area of South Broad Street; another would be west of the central business district along South Orange Avenue and Raymond Boulevard; a third, on South Broad, would cover about 410 acres and provide 26,500 housing units and one and a half million feet of new office space. All projects would tie in with the central business district and extend into the surrounding belt area.

Proposals for future studies, covering some 536 acres, lend urgency to the development of more detailed transportation and traffic plans. The city and civic groups are now discussing a state-county-city-sponsored study of freeways and streets to work out a more detailed transportation framework on which to base these projects. This study should be completed during 1960 to keep pace with renewal programs.

The state highway department is also evolving a long-range metropolitan transportation plan, similar to studies undertaken in Chicago and Philadelphia, that will take several years to complete. It is essential to the city's long-range development plans.

Today's Newark is preparing for a dynamic future. Our planning must keep pace with the march of events rapidly transforming the core of the city into a new Newark.

Transit Faces the Future

WALTER S. RAINVILLE, JR.

Mr. Rainville, Director of Research of the American Transit Association since 1945, has devoted his career to transit work. He is the author of comprehensive reports on technical aspects of transit operations and has lectured on urban transportation. For the ATA, he serves in a liaison capacity with national organizations concerned with highways and traffic. He was closely associated with the development of transit manuals for the National Committee on Urban Transportation. After years with New Orleans Public Service Inc., he held key positions with the Office of Defense Transportation in World War II. He also occupied high posts with the National Security Resources Board and the Defense Transport Administration during subsequent periods of international crisis. He is a graduate of Tulane University.

FAR from being a dying industry, as it has been characterized, transit in many cities across the United States continues to perform a highly necessary function under managements that are demonstrating an unmistakable will to live. Probably transit has been, in some areas, suffering from a combination of maladies: a long decline from the artificially high levels of patronage during World War II; a vicious nation-wide wage-price spiral, completely beyond its control; steadily increasing automobile congestion that has seriously interfered with the movement of buses on city streets, causing a deterioration in the quality of service.

A wealth of evidence indicates that various types of corrective and effective measures have prepared transit to play its role as one of the vital public services in growing urban communities. Transit managements have placed first the needs of passengers and the communities served. That policy helped transit in the process.

Recourse was had directly to the transit operating companies. Forty-eight companies in the nation's fifty largest urbanized areas were invited to tell what they have done, along with thirteen companies selected from the next largest fifty urbanized areas. Of the sixty-one companies contacted, fifty-three responded fully. The enthusiasm of the replies was most significant, indicating an obvious desire on the part of these company managements to share with

others their individual programs for improving services for the traveling public, and, to put it plainly, for staying in business.

IMPROVED SPEED AND CONVENIENCE

Transit companies have improved the speed and convenience of their services through consolidation of operations, improved routings, improved headways, improved travel time, improved traffic conditions, rapid transit improvements, the use of transit on expressways, and the operation of express and limited services on major arterial streets.

Consolidation of Operations: In the past several years there have been consolidations of properties or routes, the taking over of former private operations by municipalities and public authorities, or changes in ownership and management. Improvements in service and economies in operation resulted. Average system speeds have been increased; duplications in service have been eliminated; operator hiring procedures have been overhauled to obtain a better caliber of transit representative on the vehicle with less labor turnover.

Improved Routings: Companies have reported improvements in route patterns, extensions into growing residential areas, extensions to housing developments and outlying shopping centers. New routes have been established experimentally, with later removal of those that do not work out, and intensification of services on those that do.

Noteworthy is the trend, reversing the practice of several decades, toward through-routing in the interests of public convenience, speed, and rider appeal, as well as materially reducing the number of right- and left-hand vehicle turns in crowded downtown streets. Circuitous routings have been superseded by more direct ones. Customers have reacted appreciatively to these improvements. Where routes use a common trunk in the downtown area, buses have been spaced to eliminate long gaps at some times and the bunching of service at others.

Most reporting companies have indicated a steady program in recent years toward the elimination of feeder and shuttle services, and the substitution of direct services from residential areas to downtown, so that transit patrons may have a direct transfer-free ride.

As the result of improved routings, companies claim increased speeds up to twenty-five percent, eliminating as many as twenty-five percent of the vehicles in the business district without any decrease in service, savings in vehicle miles, hours and operating costs, and the relief of traffic congestion. In cases where slight added costs have resulted from improved routings, companies have found them offset by improvement in service and good will.

Improved Headways: Most companies make passenger checks on a regular, progressive and systematic basis, changing headways frequently to meet requirements of passenger travel. Some companies have not reduced service in proportion to decreased riding in recent years. Service has been curtailed at nights and on weekends but maintained throughout the day. While this has cost some money, one company, which serves New Orleans, believes it has maintained a high volume of riding that in turn has kept many automobiles out of the downtown area.

Two publicly-owned transit systems have deliberately maintained high standards of service and compared their riding with that of other companies that reduced services more nearly in proportion to the decrease in riding.

Chicago reduced revenue-miles 5.4 percent in the last five-year period. Nine others reduced revenue-miles by 23 percent. Eight of the other nine cities showed a reduction in maximum scheduled vehicles of 22.6 percent as compared with 10.4 percent for the test city. The average passenger loss in the nine cities over this period was thirty percent, as compared with twenty-two percent for the test city.

In Cleveland eighteen percent more vehicle miles were operated in 1955 than in 1941. Comparisons were made with four other cities similar in the number of vehicles operated, mileage, employees, and population served. For every 100 vehicles operated in 1941, this system is operating 113 vehicles today. The four comparable cities operate eighty-one vehicles, and the transit industry generally operates ninety-two, for every 100 in 1941. Figures of the U. S. Department of Commerce indicate that business-district total retail sales for this city have increased 5½ percent between 1948 and 1954, while the four comparable cities decreased nearly eight percent. Department stores alone show an increase of four percent, while the four comparable cities show a decrease of fifteen percent. Manage-

ment is confident that the city's transit operation and its high service standards have contributed substantially to this trend.

Improved Travel Time: Companies are alert to the economies inherent in increased speeds as well as improvement in passenger convenience. Companies seek improved accelerating and braking characteristics, free running speeds, ratio of horsepower to weight, etc. Operational changes conducive to improved speed and convenience are introduced, and companies co-operate fully with city and traffic officials to obtain faster movement of *all* traffic through the streets.

By the elimination of lightly used stations, by adoption of an alternate-stop plan of express train operation and the streamlining of service, by the purchase of high performance equipment and by the addition of subway facilities, Chicago Transit Authority's rapid transit trip time in rush hours has been reduced as much as thirty percent on several routes. Rush-hour traffic volume on the rapid transit system has been steadily increasing and overall traffic volume in 1959 was about three percent above 1958.

A smaller company in a highly industrial area, the Akron Transportation Company, reports line-ups of vehicles at stated intervals in the downtown area for the convenience of transferring passengers—at morning and night shift-change hours, and all-day Sundays. Considerable economy in operating cost was achieved by reducing service on several lines to conform to the line-up times and, although the interval between buses was actually lengthened, passengers were assured of direct connections without delay in travel time. Company surveys and public reaction indicate that there has actually been an over-all improvement from the riders' point of view.

IMPROVED TRAFFIC CONDITIONS

Transit companies have been working for many years with the proper public officials to free congestion in city streets, improve the flow of all vehicular traffic, and step up the speed and convenience of transit service in the more heavily-traveled urban areas.

At least eighteen companies mention reserved transit lanes in congested downtown streets, either in present operation or early prospect. Savings in travel time up of to thirty percent at certain times of day have been reported. On one route of the Nashville

Transit Company, which has had such lanes in effect since 1956, seventeen buses maintain the necessary six-minute schedule during rush periods that formerly required nineteen vehicles.

The St. Louis Public Service Company, which has not yet sold the reserved lane idea to its city, has strong press support for a plan that calls for setting aside the curb lane in the prevailing direction for rush hours only for the exclusive use of buses, together with a reversible center lane, so that motorists would not be deprived of a lane. This principle should widen the scope of application for the reserved lane idea by making it practical on two-way streets that otherwise would be one lane short of making it work.

Many companies have remained active in their programs for getting parking prohibited during rush hours in prevailing directions. This increases schedule speed. Consequently, the company performs rush-hour services with a saving in buses and operators, while giving the customer a faster ride.

Improvements have been made in signal systems and other features of the traffic control program in several cities, to facilitate the movement of buses. The Toledo Transit Company installed, several years ago, a neutral zone in the downtown section. No fares were collected in a twenty-four-block area. Loading time was immediately reduced fifty percent. All this saving could not be translated into improved travel time because of difficulty in pulling away from the curb. Passengers are enthusiastic about this plan, which attracted world-wide attention.

Co-operation by the city in establishing restricted parking regulations assisted materially. Pressure by some merchants on the city council, however, has resulted in resumption of on-street parking here and there. The company has learned that constant vigilance is needed to prevent individual merchants and special groups from nibbling away at restricted parking zones. Recently this company joined the city in an experimental try at downtown shopping malls for pedestrians.

RAPID TRANSIT IMPROVEMENTS

Specific improvement projects on rapid transit systems in New York, Chicago, Philadelphia, Boston and Cleveland have resulted in the elimination of bottlenecks and in increased capacity of the various systems for rush-hour movements. Former railroad com-

muter lines have been integrated with rapid transit systems to maintain essential services. Travel times have been improved; connecting motor bus services have been instituted. Improvements have been made in stations for customer convenience—escalators, longer platforms, improved lighting.

A most significant development has been the increase in the number of parking spaces provided adjacent to rapid transit stops, so that the passenger automobile may effectively be co-ordinated with transit for a more convenient journey to town. Such spaces become filled almost before they are ready for use—and many of the users are exclusively motorists.

Future developments in rapid transit on the West Coast are anticipated, for not all cities in that area consider the automobile freeway as an ultimate solution to the problems of movement in large metropolitan areas. In Canada, Toronto is building a second subway, to complement the Yonge Street line, opened to the public in 1954. Subways are currently being considered for Montreal and Winnipeg.

Transit on Expressways: Twelve of the responding companies reported present or anticipated use of transit on expressways. A new era in local transit history began in June 1958, when the first rail rapid transit line began operation in the median strip of a multi-lane expressway in Chicago, a joint financial undertaking of the federal, state, county, and city governments and the Chicago Transit Authority. Running time between terminals has been reduced about thirty percent. Public acceptance has been spontaneous and gratifying.

The operation of express motor bus service on expressways has reached significant proportions. More than thirty express routes are in such operation in ten cities, and more are in prospect. Buses can operate at the same speeds as automobiles; park-ride stations situated at shopping centers along the way keep many automobiles away, and aid in supporting the express service. Traffic congestion downtown is avoided for these motorists. Savings of up to thirty percent in travel time have been achieved by the operation of buses on expressways.

Express and Limited Services on Arterial Streets: Eleven transit operators have reported operation of express and limited bus services on arterial streets. Passengers approved because a fast ride is

given to and from outlying areas. In St. Louis, express service patronage has shown an increase of five percent as compared with an over-all decline in system patronage.

Travel time on such lines has been improved twenty to thirty percent over corresponding local services. City and traffic officials have co-operated in many cases to restrict parking in the curb lane to permit rapid movement of buses.

GREATER SOCIAL ACCEPTANCE

Transit managements are well aware of the great change resulting from increasing numbers and greater use of the private passenger automobile. They realize that this vehicle has become the standard of performance for the average American family in appraising local transportation services. To this end, therefore, transit has concentrated upon measures to obtain greater social acceptance of transit—not only by community officials because of its importance as an efficient mover of persons through the city streets, but also by individuals, families and common-interest groups as regular patrons thereof. It is not enough to improve speed and convenience of services, and to acquaint the public with these improvements through advertising and publicity. Imagination and ingenuity must be employed to devise and operate services tailored successfully to the needs of the individual in a motor-conscious civilization, and to get him to use them because it is the thing to do—or a thing he *can* do without dimming his prestige.

Special Express Services: The St. Louis Public Service Company, one of the pioneers in the rush-hour express service field, has based its argument upon two factors—speed, and social acceptance to the downtown worker. Express bus services, in the opinion of this operator, combine both factors. This service now comprises nineteen rush-hour express lines using 255 vehicles. Time savings of as much as thirty minutes a round trip have resulted between residential areas and downtown.

Club Bus Service: Few club bus routes are in operation, yet they are an interesting means of obtaining social acceptance for transit riding by those who prefer a high-grade prestige reserved seat service between residential areas and business centers where all-day service is not warranted. For several years, three such club bus routes have been operated successfully in Cincinnati.

Services to Shoppers: In no field has the transit operator been more active than in increasing the social acceptance of his services to the lady shopper. Shoppers' special services of many kinds have been instituted. In one form, a shoppers' special loop bus provides a fast, direct, low-cost connection between arterial lines and the shopping district, the medical and other centers. This is designed to encourage the short rider. In other forms the company operates deluxe-type off-peak express services for shoppers between residential areas and downtown at a premium fare.

Another effort to further public acceptance of transit has been through co-operation with merchants on various forms of ride-and-shop promotion. Merchants have been encouraged to survey their customers to satisfy themselves as to the dollar value of the transit shopper to the store. If the merchant provides free parking space for the shopping motorist, he should also consider a corresponding courtesy to the transit shopper.

Activities vary from special sale-days or fare-refund days, once or twice a season, to formal validation arrangements in which the customer is refunded one or more transit fares after a minimum purchase. The forms of some of these plans have changed for the better as the result of experience. Variations in approach appear endless.

A few companies have inaugurated stop-and-shop transfer privileges, both in the downtown area and in the neighborhood shopping centers.

Improved Vehicles: Not the least of the factors contributing to a greater public acceptance of transit has been the improvement of transit vehicles used in the regular services of transit companies. Operators generally have spent more money on their vehicles to give them a dressed-up appearance.

During the latter part of 1959, one manufacturer introduced a completely redesigned urban motor coach, embodying countless new features to enhance the vehicle's eye-appeal, as well as the latest mechanical improvements to insure a smooth, swift, safe ride. Fleets of these new coaches have been introduced in a number of cities, including New York, Washington, Cleveland, St. Louis, San Diego and Columbus, Ohio. Without exception, the public has responded enthusiastically.

Air-Conditioned Vehicles: Air conditioning is being tested experi-

mentally in rapid transit cars. The largest air-conditioned transit bus fleet is operated in St. Louis. Three hundred and five buses have been air conditioned for express and shopper services. During the summer of 1958, records show that air conditioning was responsible for an average of twelve percent in new transit customers on these special lines. The average daily increase in revenue on these lines during the summer was 16.4 percent. Two-thirds of this increase was retained during the winter months.

Transit-and-the-Automobile: Great interest continues in wedding the advantages of the private automobile and public transit through park-ride and courtesy-parking arrangements. Several successful ventures of this type were reported.

In Cleveland, the availability of more than 2,000 parking spaces in lots adjacent to rapid transit stations encouraged persons to ride who otherwise would have driven downtown or not gone there at all. Of the persons using the lots, seventy-one percent were new riders.

AGGRESSIVE MANAGEMENT

How important it is to the general public that transit properties be well and efficiently managed, and that they do everything in their power to help themselves? The president of the St. Louis Public Service Company puts his answer this way:

> Urban planners and engineers maintain that transit must be sustained and encouraged for the good of the community. Its efficiency in the movement of people in urban areas is essential to the economic and social welfare of these communities. Transit is, therefore, deserving of help along with other essential community services.
>
> In some cases recognition of this fact has taken the form of public ownership in order to expedite and simplify the means of community aid. This is, of course, a matter for the individual community to decide. The fact remains that there are many ways in which help can and should be provided, regardless of transit's ownership status. However, before such aid can be justified there must be some evidence that the proposed recipient has done everything reasonably within its power to help itself.

Improved Safety Experience: Nineteen companies report intensified efforts over the past several years to improve standards of safety and to reduce claims costs. Reductions in number of accidents of

up to fifty-seven percent, amounting to several million dollars a year, have been reported in the face of increases in general city traffic accidents of up to 135 percent in the same period.

Improved Public Relations: Transit companies continue to maintain and expand the various public relations techniques. These include institutional activities designed to bring the importance of transit to city officials, business leaders and the general public; informational activities designed to advise the public as to routes, schedules, special services, etc.; and employee participation programs.

There are general reports of a betterment in labor relations, more co-operation from the daily press, and better understanding on the part of governmental bodies and the riding public.

One company reports a 560 percent increase in employee commendations, a fifty percent decrease in operator complaints, and a seventy percent decrease in service complaints over an eight-year period.

Appropriate awards made to employees completing twenty-five years of continuous service, and an employee suggestion plan have produced helpful ideas for improved service, efficiency and economy.

Are these efforts beginning to pay off—efforts to make transit service faster and more convenient, to make transit riding socially acceptable, to revamp and streamline time-worn procedures in all aspects of operation, maintenance and management?

Patronage statistics compiled by the American Transit Association indicate that the answer is Yes. During the past year, a number of individual companies reported increases in the number of riders, and nationally there has been a marked softening in the decline.

The only conclusion that can be drawn from the research on which this article is based is that the transit industry is facing the future in trim and streamlined readiness:

—alert to the needs of its patrons,

—alert to the needs of the community,

—enjoying better public understanding, and

—recognized as a vital element in the practical solution of present and future transportation problems in our expanding urban areas.

The Use of Sample Survey Methods To Estimate Highway Needs

DONALD O. COVAULT

Dr. Covault has been an Associate Professor of Civil Engineering at the Georgia Institute of Technology since 1958. He is actively engaged in teaching and highway research at this institution. Previously, from 1955 to 1958, he served as a research engineer at Purdue University where he conducted a highway needs study for the state of Indiana. From 1951 to 1955 Dr. Covault was employed as a highway engineer with the Wisconsin Highway Commission. His work with this organization was primarily concerned with the design and construction of highways. Prior to 1951 he served as an instructor in Civil Engineering at the University of Colorado and Purdue University.

LARGE expenditures of money and time are required to perform a highway needs study. A typical study requires a large staff of engineering and clerical personnel. The performance of a needs study also requires exceptional co-operation between the various state, county, and city organizations if the work is to be accomplished efficiently.

The evaluation of highway needs on the county, township, and municipal street and road systems has always proved difficult because of the large mileages and low value of highway needs on these highway systems. Therefore, if every mile of highway, every bridge, and every railroad crossing in these systems are evaluated to estimate the type and cost of needs, a large expenditure of funds will be required for this evaluation.

Recent and reliable estimates of highway needs are required to do an effective job of highway administration and to effectively influence highway legislation. However, these studies are performed infrequently, if at all, because methods are time-consuming and costly. The application of sample survey techniques to the estimation of highway needs offers a means whereby the shortcomings of conventional procedures may be overcome. Sample survey procedures are especially adaptable to the estimation of needs on the county, township, or municipal highway systems because of the

lack of necessity for detailed knowledge about specific needs for every mile of highway.

Complete highway needs data for the county primary road system in Michigan and Minnesota were available for recent highway needs studies. This information was used to develop methodology and techniques for the estimation of total cost highway needs on a state-wide basis using sample survey theory. The four different sampling plans investigated are as follows:

1. Simple random sampling.
2. Stratified random sampling with optimum and proportional allocation of the sampling units in the various strata.
3. Simple cluster sampling.
4. Stratified cluster sampling with optimum and proportional allocation in the various strata.

ANALYSIS OF DATA

Description of Populations: The county primary highway system was considered to be composed of six separate populations. These six were all highway sections, all bridges, and all railroad crossings on the rural system and all highway sections, all bridges, and all railroad crossings on the urban system. Each of these separate populations was sampled separately and the results added to obtain an estimate of the total cost on needs for the entire country road system in a state.

When simple random or stratified random sampling was used, the sampling unit for the highway population was the highway section; the sampling unit for the bridge population was the bridge; and the sampling unit for the railroad crossing population was the railroad crossing. The county was used as the sampling unit for simple and stratified cluster sampling and the highway sections, bridges, and railroad crossings contained in the county were called elements. All of the elements in a sampled county would be evaluated when estimates of total cost of needs were desired.

For some evaluations another population was used. This population was composed of all highway sections where each section included all the bridges and railroad crossings in it. This type of population was referred to as composite population. The total cost of improvement of a highway section in such a population therefore

included the cost of improvement of the highway section plus the cost of improvement of bridges and railroad crossings which were located within the section.

Order of Accuracy: Of essential importance to any sample survey is an objective choice of accuracy desired in the estimated cost of highway needs. The greater the error tolerated, the smaller will be the required sample size to estimate the cost of needs. If one desired a very precise estimate of the total cost of needs, very large sample sizes, or even the entire population, must be evaluated. The agency using the results of a highway needs study must make the decision as to the accuracy desired in the estimate. This decision must be based on a careful consideration of the eventual use of the estimated information by various administrative agencies and the cost and time expenditure in making the survey.

Specifically, the order of accuracy of a sample survey can be expressed in terms of a margin of error d_T in the estimated total and a small risk α that the actual error is larger than the margin of error d_T. Alternately, the sample size is sometimes specified as large enough to provide a confidence interval of one-half width d_T, with a confidence probability of $(1\text{-}\alpha)$. Expressed in terms of a probability equation, the order of accuracy of a sample survey can be stated as follows:
The symbols are defined as follows:

$$\Pr\left[|\hat{Y} - Y| \geq d_T\right] = \alpha \qquad (1.0)$$

$\hat{Y}$ = Estimated total
Y = Total population value
d_T = Margin of error in estimated total
α = Risk that the actual error is larger than the margin of error.

Basic Data: The type of basic data required to make a sample survey will generally depend upon the type of sampling methods used. Certain data, however, such as transportation maps, soils data, cost records and so forth are required information for all types of sampling methods.

Simple Random Sampling: To use simple random sampling, the sampling units that compose the various populations must be completely located and identified. In Figure 1 is shown a county transportation map for Missaukee County, Michigan. On this map are

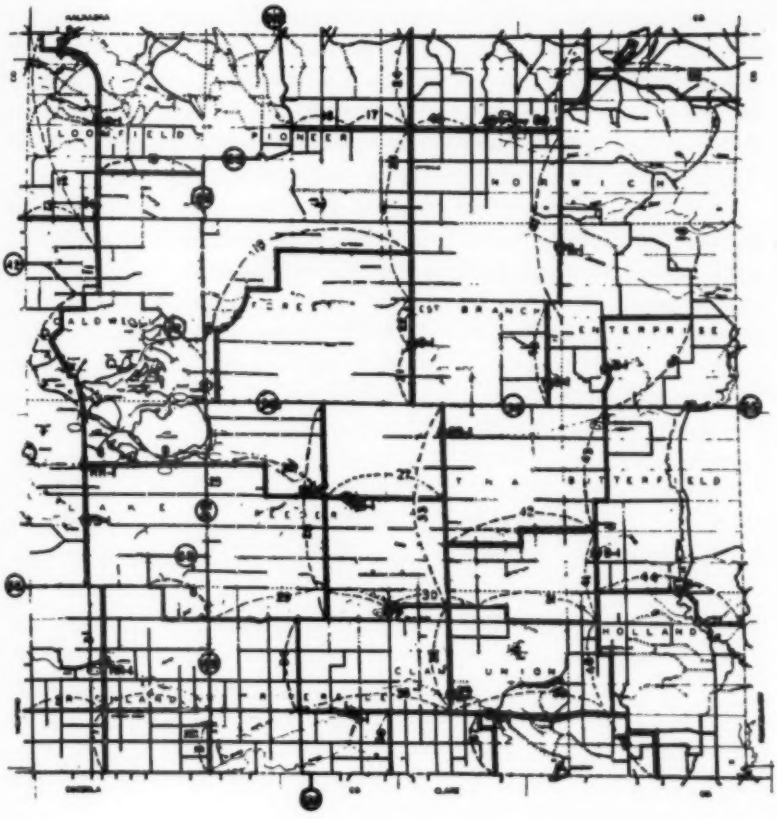

Figure 1. County Primary Roads, Missaukee County, Michigan (3).

situated the various road sections, bridges, and railroad crossings located on the county primary road system. Similar identification of highway sections, bridges and railroad crossings must be made for every county within the state. Generally, the various county engineers in the state are the individuals best qualified to choose the termini of the various road sections because they are intimately familiar with the proper termini of each road project.

To draw a random sample, the information contained on the transportation maps must be listed on punch cards or some other card capable of being drawn at random. A single card is made for each highway section, bridge, and railroad crossing and enough identification information is placed on each card to permit location of the project on the transportation map. A random number can be assigned to each unit in the respective populations and the sample can be drawn on the assigned random number. The sample can be drawn manually or by business machines with equal randomness.

After the sample is drawn for each population, the highway sections, bridges and railroad crossings contained in the samples for the respective populations are located on the transportation map. A complete inventory of highway sections, bridges and railroad crossings located in the sample is made, and each inventoried unit is evaluated for the type and cost of improvement required. The total cost of needs for the various populations can then be estimated from the information in this sample by the following formulas:

$$\hat{Y} = N\bar{y} \tag{2.0}$$

where

$$\bar{y} = \frac{y}{h} \tag{3.0}$$

The symbols in these two equations are defined as follows:

$\hat{Y}$ = Estimate of the population total

N = Total number of sampling units in the population

$\bar{y}$ = Estimate of the population mean obtained from the sample

n = Number of sampling units in the sample

y = Total value of population characteristic (total cost of needs) in the sample.

Stratified Random Sampling: Stratified random sampling requires more information for listing of sampling units in the various popula-

tions than does simple random sampling. In addition to the information required for simple random sampling, enough data to permit stratification of the populations are needed. The separate highway populations on the rural county road systems were stratified on the basis of topography and traffic volume. Other populations were stratified either on traffic volume or population. Figures 2 and 3 illustrate the method of stratification of the separate and composite populations.

A separate card must be made for each road section, bridge and railroad crossing, as was previously described for simple random sampling. However, additional information to permit stratification of the population must be added to the card. If one desires to stratify the population, adequate data must be available. For example, traffic flow and topographic data must be available for each highway section to adequately stratify the population.

The sample in each stratum is randomly drawn by assigning a random number to each card in the respective populations and choosing the units manually or by business machines. Similar to the procedure used for simple random sampling, the chosen units are inventoried and evaluated to determine the needs and the total cost of needs. The total needs for all strata (h to L) in the entire population is estimated from this sample by the following formula:

$$\hat{Y} = \sum_{h}^{L} N_h \bar{y}_h \tag{4.0}$$

where

$$\bar{y}_h = \frac{y_h}{n_h} \tag{5.0}$$

$\hat{Y}$ = Estimated total population characteristic

y_h = Value of the population characteristic in the sample in the hth strata

n_h = Number of sampling units in the sample in the hth stratum

N_h = Total number of sampling units in the hth stratum

$\bar{y}_h$ = Estimate of mean obtained from the sample in the hth stratum.

Simple Cluster Sampling: Usually information required for the selection of a simple cluster sample is very easy and economical to obtain. Because the county was used as the sampling unit for this method of sampling, only the name and location of each county was

RURAL HIGHWAY SYSTEMS

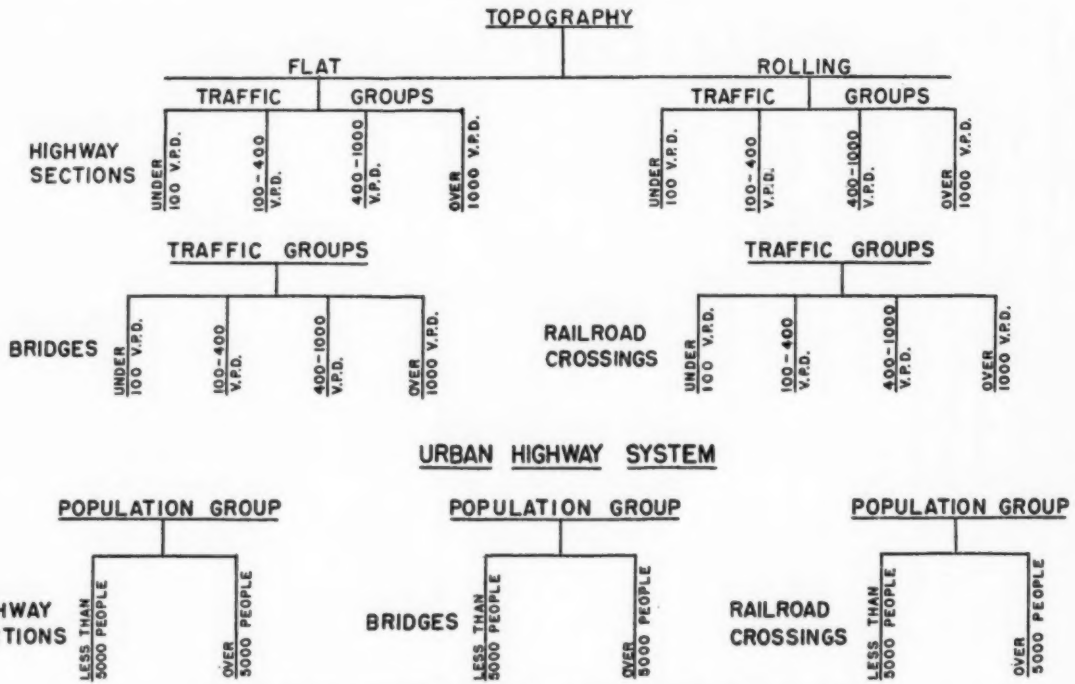

DIAGRAM OF STRATIFICATION OF SEPARATE POPULATIONS
FOR THE RURAL AND URBAN HIGHWAY SYSTEM

Figure 2.

required in each state. To choose the counties which would be included in a sample, it was only necessary to draw a simple random sample of the counties in the respective states.

To evaluate the needs for each sampled unit, all highway sections, bridges, and railroad crossings in the cluster (county) would be inventoried and evaluated for total cost of improvement. A similar inventory would be made for all other chosen sampling units. The total cost for the various needs in the sample would be used to estimate the needs for all of the highway sections, bridges, and railroad crossings in the state. The formula used is:

$$\hat{Y} = \frac{N}{n} \sum_{i}^{n} Y_i \tag{6.0}$$

$\hat{Y}$ = Estimate of the population total

N = Total number of sampling units (counties) in the population

n = Number of sampling units (counties) in the sample

Y_i = Total value of the population characteristic in the ith sampled unit.

Stratified Cluster Sampling: Additional data are required to use stratified cluster sampling. Criteria for the choice of strata must be easily obtained and highly correlated with the population characteristic to be estimated. Various economic data for each county, such as annual gasoline sales, annual retail sales, gasoline sales per square mile and so forth were investigated to estimate the correlation between these factors and total cost of highway improvements. The correlation between county highway mileage on the rural road system and the total cost of county highway improvements was also studied. The highest correlation found was that between rural county road mileage and the total cost of improvements, and this variable was used as the basis of stratification in this study.

Three strata were chosen for the data in each state so that the total cost of needs within each strata were approximately the same. The following mileage groups for the various strata were used:

Stratum Number	*Mileage Group*
1	0—249.99 Miles
2	250.00—349.99 Miles
3	350.00—Maximum Miles

The sample in each strata is drawn in the same manner as is

Figure 2.

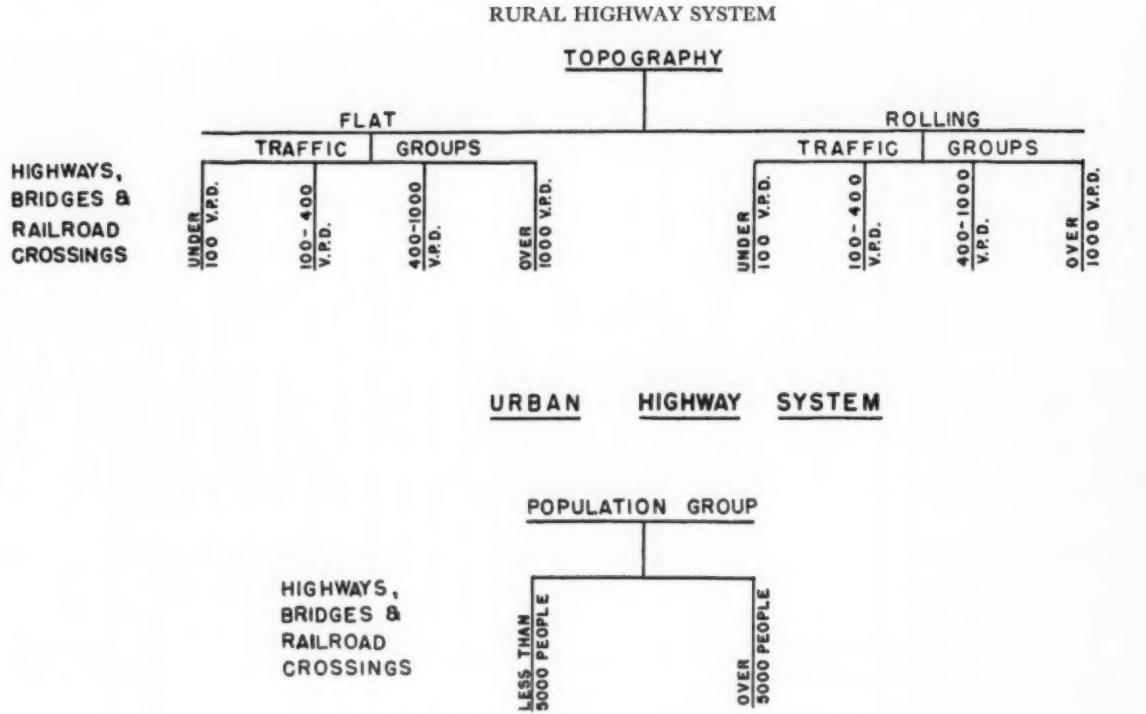

DIAGRAM OF THE STRATIFICATION OF THE COMPOSITE POPULATIONS FOR THE RURAL AND URBAN HIGHWAY SYSTEMS

Figure 3.

used for simple cluster sampling. The total cost of needs for each population is evaluated from this sample according to the following formula:

$$\hat{Y} = \sum_{h}^{L} \frac{N_h}{n_h} \sum_{L}^{n_h} Y_h \qquad (7.0)$$

The symbols are defined as follows:

$\hat{Y}$ = Estimate of total population total

N_h = Total number of sampling units (counties) in the hth stratum

n_h = Number of sampling units in the sample in the hth stratum

Y_h = Total value of the population characteristic of the sample in the hth stratum.

COMPUTATION OF SAMPLE SIZE

Variance of the Estimate of the Total: Because complete needs study data were available in Michigan and Minnesota, population and strata variances for total cost of needs could be computed. Furthermore, an exact value for the margin of error, d_T could be computed as a percentage of the total cost because total cost values were available.

The variance for the estimate of the total is

$$V(\hat{Y}) \cong \frac{d_T^2}{Z^2_{(1-\alpha)}} \qquad (8.0)$$

where $Z_1-\alpha$ is the value obtained from the normal distribution.

Simple Random Sampling: The formula for sample size for simple random sampling is:

$$n = \frac{\dfrac{N^2S^2}{V(\hat{Y})}}{1 + \dfrac{1}{N}\left(\dfrac{N^2S^2}{V(\hat{Y})}\right)} \qquad (9.0)$$

where S^2=population variance. The population variance is evaluated by the following formula:

$$S^2 = \frac{\sum_{i}^{N} (y_i - \bar{Y})^2}{N-1} = \frac{N\sum_{i}^{N} y_i^2 - \left(\sum_{i}^{N} y_i\right)^2}{N(N-1)} \qquad (10.0)$$

where the symbols are defined as follows:

y_i = Value of the ith unit

$\bar{Y}$ = Population mean.

Example 1 illustrates the computations required for sample size for the separate highway population when the margin of error d_T is ten percent of the total cost and the α risk=0.10. The total number of sampling units in the highway population is 6,321 road sections and the total cost of improvement for these road sections for a twenty-year road improvement program is $536,722,000.

EXAMPLE I. COMPUTATION OF SAMPLE SIZE-RURAL HIGHWAY POPULATION SIMPLE RANDOM SAMPLE—MICHIGAN DATA

Sample Size for Estimating Total Cost

Margin of Error and α Risk: d_T = 10 Percent of Total Cost; α = 0.10

Total Cost ($1000)	Total Number Sampling Units N	$\left(\sum_i^N y_i\right)^2$	$\sum_i^N y_i^2$	$S^2 = \dfrac{N\sum_i^N y_i^2 - \left(\sum_i^N y_i^2\right)^2}{N(N-1)}$	Sample Size n
536,722	6,321	288,070,505,284	90,273.656	7,073	254

Computation of Population Variance:

$$\text{Formula (10.0):}\quad S^2 = \frac{\sum_i^N (y_i - \bar{Y})^2}{N-1} = \frac{N\sum_i^N y_i^2 - \left(\sum_i^N y_i\right)^2}{N(N-1)}$$

$$= \frac{6{,}321 \times 90{,}272{,}656 - 288{,}070{,}505{,}284}{6{,}321(6{,}321-1)} = 7{,}073$$

Computation of Sample Size:

$$d_T = 0.10 \times 536{,}772 = 53{,}672;\ Z = 1.6448,\ Z^2 = 2.7054$$

$$\text{Formula (8.0):}\quad V(\hat{Y}) = \frac{d_T^2}{Z^2} = \frac{(53672)^2}{2.7054} = 1068 \times 10^6$$

$$\frac{N^2S^2}{V(\hat{Y})} = \frac{(6321)\ 7073}{1068 \times 106} = 265$$

$$\text{Formula (9.0):}\quad n = \frac{265}{1 + \frac{1}{6321}(265)} = 254$$

The value of the population variance is 7,023 and the variance of the estimate of the total is 1,068 x 10^6. The computed sample size is found to be 254 highway sections. The sampling rate (number of sampled units divided by the total number of sampling units) required for this accuracy is 4.0 percent. Similar computations can also be made for the bridge and railroad crossing populations.

In the conduct of actual sample surveys, the total value of the population characteristic (total cost) being estimated and the value of the population variance S^2 are never known. Therefore, these values must be estimated before a margin of error d_T can be assigned and a sample size computed. A value for d_T can be estimated from previous highway needs studies made on the entire population or from complete needs studies made in states with similar highway requirements. An estimate of the population variance can also be obtained in this manner or it can be obtained from a preliminary sample of the population. The value of estimate of the population variance is expressed by the following formula:

$$s^2 = \frac{\sum_i^n (y_i - \bar{Y})^2}{s - 1} = \frac{n \sum_i^n y_i^2 - \left(\sum_i^n y_i\right)^2}{n(n-1)} \qquad (11.0)$$

The value of s^2 is an unbiased estimate of the population variance S^2. If the value of the sample size n is less than 30, the value of the $Z_{1-\alpha}$ value in equation (8.0) for the computation of the variance of the estimate of the total must be replaced by the $t_{(1-\alpha)}$ value obtained from the t—distribution. The number of degrees of freedom used to determine the value of t is equal to $(n-t)$. The sample size required for a specified margin of error and α risk when the t value must be used in equation (8.0) can be computed by trial and error.

Because S^2 must be estimated from previous data or from the sample, the calculations for n does not provide any assurance that the margin of error will be of desired size. Stien (1955) developed a method using an estimate of S^2 obtained from the population being sampled which guarantees that the margin of error will be no greater than a specified amount. The sample is taken in two parts. The first sample supplies an estimate of S^2 and a preliminary estimate of Y. The additional number of observations needed for a specified margin of error is then calculated.

Stratified Random Sampling: Stratified random sampling with optimum and proportional allocation of sampling units among the various strata was used in this study. Optimum allocation of the units in the sample among the various strata will provide a sample of smaller size than that obtained for proportional allocation of the

units among the various strata. Stated in terms of a formula, optimum and proportional allocation of the sample among the various strata is expressed as follows:

(a) Optimum Allocation

$$n_h = \frac{N_h S_h}{\sum_h^L N_h S_h} n \tag{12.0}$$

(b) Proportional Allocation:

$$n_h = \frac{N_h}{N} n \tag{13.0}$$

The symbols are defined as follows:

n_h = number of sampling units in the sample in the hth stratum
Y_h = Standard deviation of the stratum
S_h = total number of sampling units in the hth stratum
n = total sample size i.e.

$$n = \sum_i^L n_h$$

The stratum variance S_h^2 is computed by the following formula:

$$S_h^2 = \frac{\sum_i^{N_h} (y_{hi} - \bar{Y}_h)^2}{N_h - 1} = \frac{N_h \sum_i^{N_h} y_{hi}^2 - \left(\sum_i^{N_h} y_{hi}\right)^2}{N_h(N_h - 1)} \tag{14.0}$$

The symbols are defined as follows:

y_{hi} = value of the ith unit in the hth stratum
$\bar{Y}_h$ = stratum mean

The variance of the estimate of the total can be expressed by equation (8.0). Using this variance, the formulas for sample size are expressed by the following equations:

Optimum allocation:
$$n = \frac{\left(\sum_i^L N_h S_h\right)^2}{V(\hat{Y}) + \sum_h^L N_h S_h^2} \tag{15.0}$$

Proportional allocation:
$$n = \frac{\frac{N}{V(\hat{Y})} \sum_h^L N_h S_h^2}{1 + \frac{1}{N}\left(\frac{N}{V(\hat{Y})} \sum_h^L N_h S_h^2\right)} \tag{16.0}$$

Example 2 illustrates the computations required to compute sample sizes for optimum and proportional allocation for the separate highway population when the margin of error d_T is ten percent of the total cost and the α risk is 0.10. The computed sample size for stratified random sampling with optimum allocation is 208 units and for proportional allocation 240 units. The allocation of these sample sizes among the various strata is also shown in Example 2.

EXAMPLE II. COMPUTATION OF SAMPLE SIZE-RURAL HIGHWAY POPULATION-STRATIFIED RANDOM SAMPLE-MICHIGAN DATA SAMPLE SIZE FOR THE ESTIMATE OF TOTAL COST

Margin of Error and α Risk: d_T = 10 Percent of Total Cost; α = 0.10

STRATUM		Total Cost ($1000) $\sum_i^{N_h} y_{hi}$	Total No. in Stratum, N_h	$\left(\sum_i^{N_h} y_i\right)^2$	$\sum_i^{N_h} y_i^2$
Topography	1975 Traffic				
Flat	Under 100 V.P.D.	19,872	264	394,896,384	2,434,900
	100–400 V.P.D.	127,481	1,727	16,251,405,361	15,636,195
	400–1000 V.P.D.	99,422	1,201	9,884,734,084	15,176,142
	Over 1000 V.P.D.	110,599	881	12,232,138,801	28,922,813
Rolling	Under 100 V.P.D.	11,930	188	142,324,900	1,252,914
	100–400 V.P.D.	71,268	1,003	5,079,127,824	8,194,082
	400–1000 V.P.D.	41,955	620	1,760,222,025	4,485,685
	Over 1000 V.P.D.	54,195	437	2,937,098,025	14,170,925
Total		536,722	6,321		

Optimum Sampling:

Computation of Total Sample Size:

For d_T = 10 Percent of total cost = 53,672; α = 0.10; Z = 1.6448, Z^2 = 2.7054

$$\text{Formula (8.0):} \quad V(\hat{Y}) = \frac{d_T^2}{Z^2} = \frac{(53.672)^2}{2.7054} = 1068 \times 10^6$$

Sample Size:

$$\text{Formula (15.0):} \quad n = \frac{\left(\sum_h^L N_h S_h\right)^2}{V(\hat{Y}) + \sum_h^L N_h S_h^2} = \frac{(480{,}684)^2}{1068 \times 10^6 + 41{,}926{,}997} = 208$$

Computation of Stratum Sample Size:

Stratum: Under 100 V.P.D.

$$\text{Formula (12.0):} \quad n_h = \frac{N_h S_h}{\sum_h^L N_h S_h} n = \frac{15{,}577}{480{,}684} \times 208 = 7$$

EXAMPLE II, *continued*

Margin of Error and α Risk: d_T = 10 Percent of Total Cost; α = 0.10

$S_h^2 = \frac{N\sum_i^{N_h} y_i^2 - \left(\sum_i^{N_h} y_i\right)^2}{N_h(N_h-1)}$	S_h	N_hS_h	$N_hS_h^2$	Stratum Sample Size, n_h	
				Optimum	Proportional
3,571	59.76	15,577	942,744	7	10
3,607	60.06	103,724	6,229,289	45	66
5,788	76.08	91,372	6,951,388	40	46
17,089	130.7	115,173	15,055,409	50	33
2,652	51.50	9,682	498,576	4	7
3,124	55.89	56,058	3,133,372	24	38
2,660	51.57	31,973	1,649,200	14	24
17,087	130.7	57,125	7,467,019	24	17
Total		480,684	41,926,997	208	240

Proportional Sampling:

Computation of Total Sample Size:

$$\frac{N}{V(\hat{Y})}\sum_h^L N_hS_h^2 = \frac{6321 \times 41{,}926{,}997}{1{,}065{,}861{,}935} = 249$$

Formula (16.0): $$n = \frac{249}{1 + \frac{249}{6321}} = 240$$

Computation of Stratum Sample Size:

Stratum: Under 100 V.P.D.

Formula (13.0): $$n_h = \frac{N_h}{N}n = \frac{264}{6321} \times 240 = 10$$

Because stratum variances and the value of d_T as a percentage of the total cost are not precisely known in an actual sample survey, these values must be estimated from previous data or preliminary samples. An unbiased estimate of the stratum variance can be obtained from a sample taken in the stratum by using the following formula:

$$s_h^2 = \frac{\sum_i^{n_h}(y_{hi} - \bar{y}_h)^2}{n_h - 1} = \frac{n_h\sum_i^{n_h} y_{hi}^2 - \left(\sum_i^{n_h} y_{hi}\right)^2}{n_h(n_h-1)} \qquad (17.0)$$

The $Z_{(1-\alpha)}$ value obtained from the normal distribution used in equation (8.0) to compute the variance of the estimate must be replaced with the $t_{(1-\alpha)}$ value with an appropriate number of degrees of freedom. The number of degrees of freedom for all strata is called the effective number of degrees of freedom and can be ap-

proximated by using a method developed by Satterthwaite. The effective number of degrees of freedom is expressed by the following formula:

$$n_e = \frac{\left(\sum_h^L f_h s_h^2\right)^2}{\sum_h^L \frac{f_h^2 s_h^4}{n_h - 1}} \tag{18.0}$$

where

$$f_h = \frac{N_h(N_h - n_h)}{n_h} \tag{19.0}$$

A comparison of the sample sizes and sampling rates for the two examples illustrated for simple random and stratified random sampling is shown in Table 1.

TABLE 1.—SAMPLE SIZES AND SAMPLING RATES FOR HIGHWAY COST

	Type of Sampling		
	Simple Random	*Stratified Random*	
		Optimum	*Proportional*
Sample Size	254	208	240
Sampling Rate $(\frac{N}{n}100)$	4.0%	3.3%	3.8%

It is apparent that stratification of the highway population only causes a slight reduction in sample size required for a margin error of ten percent of the total and an α risk of 0.10.

Simple Cluster Sampling: Because the sampling unit in this study is the county, the elements in the cluster were the highway sections, bridges, and railroad crossings contained in the county. Sample size for simple cluster sampling is computed by the following formula:

$$n = \frac{\frac{N^2 S_T^2}{V(\hat{Y})}}{1 + \frac{1}{N}\left(\frac{N^2 S_T^2}{V(\hat{Y})}\right)} \tag{20.0}$$

the symbols are defined as follows:

n = number of sampled units (counties)

N = number of sampling units (counties) in the population

$V(\hat{Y})$ = Variance of the estimate of the total as defined by equation (8.0)

S_T^2 = Population variance

The population variance is derived by the following equation:

$$S_T^2 = \frac{\sum_i^N (Y_i - Y)^2}{N-1} = \frac{N\sum_i^N Y_i^2 - \left(\sum_i^N Y_i\right)^2}{N(N-1)} \qquad (21.0)$$

The symbols are defined as follows:

S_T^2 = Population variance

Y_i = Total value of the population elements in the sampled county.

EXAMPLE III. COMPUTATION OF SAMPLE SIZE COMPOSITE RURAL POPULATION USING SIMPLE CLUSTER SAMPLING-MICHIGAN DATA

Margin of Error and α Risk: d_T = 10 Percent of the Total, α = 0.10

Total Cost ($1000)	Total Number Sampling Units N	$\left(\sum_i^N Y_i\right)$	$\sum_i^N Y_i^2$	$S_T^2 = \frac{N\sum_i^N Y_i^2 - \left(\sum_i^N Y_i\right)^2}{N(N-1)}$	Sample Size n
603,486	83	$364{,}195 \times 10^6$	6997.5×10^6	31.82×10^6	55

Computation of Population Variance:

Formula (21.0): $$S_T^2 = \frac{\sum_i^N (Y_i - Y)^2}{N-1} = \frac{N\sum_i^N Y_i^2 - \left(\sum_i^N Y_i\right)}{N(N-1)}$$

$$S_T^2 = \frac{83 \times 6997.5 \times 10^6 - 364{,}195 \times 10^6}{83(82)} = 31.82 \times 10^6$$

Computation of Sample Size:

$$d_T = 0.10 \times 603{,}486 = 60{,}348;\ Z = 1.6448;\ Z^2 = 2.7054$$

Formula (8.0): $$V(\hat{Y}) = \frac{d_T^2}{Z^2} = \frac{(60{,}348)^2}{2.7054} = 1346 \times 10^6$$

$$n = \frac{N^2 S_T^2}{V(Y)} = \frac{(83)^2 \times 31.82 \times 10^6}{1346 \times 10^6} = 162.7$$

Formula (20.0): $$n = \frac{162.6}{1 + 162.7/83} = 55$$

Example 3 illustrates the computations required for the total cost of all improvements (highways, bridges, and railroad crossings) for d_T=ten percent of the total and α=0.10 using the composite population. Similar computations can be made for the separate

highway, bridge, and railroad crossing populations as was shown in Examples 1 and 2 for sample and stratified random sampling.

In Example 3, the total cost is $603,486,000 for the 83 counties in the Michigan data. The population variance is 31.82×10^6. The computed sample size is 55 units. Similar computations made on the separate highway population for d_T=ten percent of the highway cost and an α=0.10 also requires a sample size of 55 units.

When an actual sample survey is made, the value of the population variance S_T^2 must be estimated from previous data or from preliminary samples. The method for determining the variance of the estimate as expressed by Equation 8.0 must be revised. The $Z_{(1-\alpha)}$ value must be replaced with the $t_{(1-\alpha)}$ value with an appropriate number of degrees of freedom. Stien's method described previously for random sampling may be used to determine the required sample size so that the margin of error will not be larger than a specified amount in the sample survey.

Stratified Cluster Sampling: Three variations of stratified cluster sampling were used in this study. These were as follows:

(1) Proportional allocation, where the number of units sampled in each stratum is proportional to the total number of sampling units (counties) in the stratum, i.e.

$$n_h = \frac{N_h}{N} \tag{22.0}$$

(2) Proportional allocation, where the number of units sampled in each stratum is proportional to the number of elements in each stratum

$$n_h = \frac{M_h}{M} n \tag{23.0}$$

The symbols are defined as follows:

M_h= number of elements in the hth stratum

M = number of elements in the population

(3) Optimum allocation where the number of sampled units in stratum is expressed by the following equation:

$$n_h = \frac{N_h S_{hT}}{\sum_h^L N_h S_{hT}} n \tag{24.0}$$

where S_{hT} is the standard deviation for the hth stratum. The value of this variance is expressed by the following equation:

$$S_{hT}^2 = \frac{\sum_{i}^{N_h} (Y_{hi} - \bar{Y}_h)^2}{N_h - 1} = \frac{N_h \sum_{i}^{N_h} Y_{hi}^2 - \left(\sum_{i}^{N_h} Y_{hi}\right)^2}{N_h(N_h - 1)} \qquad (25.0)$$

Sample sizes for these methods of allocation are computed by the following equations:

(1) Proportional allocation, $n_h \propto N_h$

$$n = \frac{N \sum_{h}^{L} N_h S_{hT}^2}{V(\hat{Y}) + \sum_{h}^{L} N_h S_{hT}^2} \qquad (26.0)$$

(2) Proportional allocation, $n_h \propto M_h$

$$n = \frac{M \sum_{h}^{L} \frac{N_h^2 S_{hT}^2}{M_h}}{V(\hat{Y}) + \sum_{h}^{L} N_h S_{hT}^2} \qquad (27.0)$$

(3) Optimum allocation $n_h \propto N_h S_{hT}2$

$$n = \frac{\left(\sum_{h}^{L} N_h S_{hT}\right)^2}{V(\hat{Y}) + \sum_{h}^{L} N_h S_{hT}^2} \qquad (28.0)$$

Example 4 illustrates the computations required to compute sample sizes for the two forms of proportional sampling and for optimum sampling. The sample sizes computed in this example are for the estimate of total cost of all improvements (highways, bridges, and railroad crossings) for a margin of error d_T ten percent of the total and α=0.10 for the composite population. The computed sample sizes for the various forms of stratified cluster sampling are as follows:

Optimum	31
Proportional, $n_h \propto N_h$	43
Proportional, $n_h \propto M_h$	36

Similar computations made for the estimate of cost of the separate

highway population for $d_T =$ ten percent of total and $\alpha = 0.10$ required the following sample sizes:

Optimum	30
Proportional, $n_h \propto N_h$	43
Proportional, $n_h \propto M_h$	37

The high sampling rates shown in Table II indicate the impracticability of the use of the county as a sampling unit for highway needs evaluation.

TABLE II. SAMPLE SIZES AND SAMPLING RATES FOR HIGHWAY COST

	Type of Sampling			
	Simple Cluster	*Optimum Cluster*	*Proportional Cluster* $n_h \propto N_h$	$n_h \propto M$
Sample Size	55	30	43	37
Sampling Rate $\left(\frac{n}{N} \times 100\right)$	66.2%	36.1%	51.8%	44.6%

In actual sample surveys the value of S_{hT}^2 and d_T must be estimated. The variance of the estimate expressed by equation (8.0) must be computed using the t-distribution instead of the Z-distribution. The effective degrees of freedom expressed by equations (18.0 and 19.0) can be used to obtain the value of the t-distribution. An estimate of the stratum variance S_{hT}^2 can also be obtained from a preliminary sample.

COST OF SAMPLE SURVEYS

Of basic importance in the choice of a sampling plan is the need of proper cost information in making a sample survey. The total cost of sample survey is composed of several separate costs including those due to overhead and general supervision, sampling unit listing, travel, data collection, and data analysis. These costs will vary not only with the sample size but also with the type of sampling used.

Included in the cost of overhead and administration is the cost of office space, utilities, paper and so forth. Also included is the cost of general planning administration, and clerical help. For the purposes of cost comparisons, this cost can be assumed to be the same for all sampling and shall not be included in the cost computations for the various sampling plans.

EXAMPLE IV. COMPUTATION OF SAMPLE SIZE-COMPOSITE RURAL HIGHWAY POPULATION-STRATIFIED CLUSTER SAMPLE MICHIGAN DATA

Sample Size for Estimating Total Cost: (All Highway, Bridge, and Railroad Crossing Improvements)

Margin of Error and α Risk: d_T = 10 Percent of Total Cost, $\alpha = 0.10$

Stratum: County Primary Mileage		Total Cost ($1000)	Number Primary Units N_h	Number of Elements M_h	$\left(\sum_i^N Y_{hi}\right)^2$	$\left(\sum_i^N Y_{hi}\right)^2$
0–249.99	(1)	153,316	41	1,908	23,505,795,856	642,768,142
250–349.99	(2)	281,176	30	2,738	79,059,942,976	3,508,853,496
350–Maximum	(3)	168,994	12	1,675	28,558,972,036	2,545,927,266
Total		603,486	83	6,321	364,195,352,196	

Optimum Sampling:

Computation of Stratum Sample Sizes:

For d_T = 10 Percent Total Cost = 60,349; $Z = 1.6448$, $Z^2 = 2.7054$

Formula (8.0): $$V(\hat{Y}) = \frac{d_T^2}{Z^2} = \frac{(60340)^2}{2.7054} = 1{,}346 \times 10^6$$

Formula (24.0): $$n_h = \frac{N_h S_{hT}}{\sum_h^L N_h S_{hT}}\, n$$

Formula (28.0): $$n = \frac{\left(\sum_h^L N_h S_{hT}\right)^2}{V(\hat{Y}) + \sum_h^L N_h S_{hT}^2} = \frac{84{,}972{,}250{,}000}{1346 \times 10^6 + 1{,}466{,}349{,}014} = 30$$

For Stratum 1: $$n_h = \frac{54{,}038}{291{,}500} \times 30 = 6$$

EXAMPLE IV, *continued*

Sample Size for Estimating Total Cost: (All Highway, Bridge, and Railroad Crossing Improvements)

Margin of Error and α Risk: d_T = 10 Percent of Total Cost, α = 0.10

$S_{hT}^2 = \frac{N_h \sum_i^{N_h} Y_{hi} - \left(\sum_i^{N_h} Y_{hi}\right)^2}{N_h(N_h - 1)}$	S_{hT}	$N_h S_{hT}$	$N_h S_{hT}^2$	$\frac{N_h^2 S_{hT}^2}{M_h}$	Optimum n_h	Sample Sizes Proportional $n_h \propto N_h$ n_h	Sample Sizes Proportional $n_h \propto M_h$ n_h
1,736,854	1,318	54,038	71,311,014	1,530,216	6	21	11
40,465,000	6,361	190,830	1,213,950,000	13,301,132	20	16	16
15,099,000	3,886	46,632	181,188,000	1,298,063	5	6	9
Total		291,500	1,466,349,014	16,129,411	31	43	36

Proportional Sampling:

($n_h \propto N_h$)

Formula (26.0): $$n = \frac{N \sum_h^L N_h S_{hT}^2}{V(\hat{Y}) + \sum_h^L N_h S_{hT}^2}$$

$$n = \frac{83 \times 1{,}466{,}349{,}014}{1{,}346 \times 10^6 + 1{,}466{,}349{,}014} = 43$$

Computation of Stratum Sample Sizes:

Formula (22.0): $$n_h = \frac{N_h}{N} \times n$$

For Stratum 1: $$n_h = \frac{41}{83} \times 43$$

$$n_h = 21$$

Proportional Sampling

($n_h \propto M_h$)

Formula (27.0): $$n = \frac{M \sum_h^L \frac{N_h^2}{M_h} S_{hT}^2}{V(\hat{Y}) + \sum_h^L N_h S_{hT}^2}$$

$$n = \frac{6321 \times 16{,}129{,}411}{1{,}346 \times 10^6 + 1{,}466{,}349{,}014} = 36$$

Formula (23.0): $$n_h = \frac{M_h}{M} \times n$$

For Stratum 1: $$n_h = \frac{1908}{6321} \times 36$$

$$n_h = 11$$

The listing of a sampling unit requires finding the location of the termini of each highway section, bridge, and railroad crossing on a map; writing a description of their location; determining traffic volume if required; punching or writing the information on a card; and checking the information for errors. For simple and stratified random sampling this listing process must include every highway section, bridge, and railroad crossing in the highway system under study. On the other hand, complete listing need only occur in the units (counties) which are sampled when cluster sampling is used.

Travel cost does not vary directly with sample size. The larger the number of sampled units in a state, the smaller the unit cost of travel. The unit cost of travel should include several components. In addition to the expense of driving a vehicle from one sampling unit to another, the salaries earned by the survey crew while traveling must be included. Travel to and from headquarters and subsistence for overnight stay away from headquarters are also included in travel expense.

Salaries and wages paid to the survey crew for gathering information during the collection of inventory data on a highway system are included in data collection costs. Also included in these costs are travel costs incurred while gathering information in the sampled section.

Included in data analysis costs, in addition to the actual statistical computations, is the cost of choosing the sample, evaluating inventory data, coding and placing information on punch cards, and checking and preparing the final reports.

When the highway sections, bridges, and railroad crossings are treated as separate populations, the evaluation of the needs for each population consists of a separate sample survey. The total survey cost for a particular road system is the sum of the costs for the sampling and analysis of each highway, bridge, and railroad crossing population.

These populations are not totally independent however, if the following procedure is used in collecting data. If bridges or railroad crossings are located in a sampled highway section, these bridges and railroad crossings may be "forced" into the bridge and railroad crossing sample. If one assumes that each highway section contains

one bridge and one railroad crossing, or one bridge and no railroad crossing, or no bridge and one railroad crossing, or no bridge or railroad crossing at all, any bridge and railroad crossing which is included in the sampled highway section will be chosen at random.

Because some road sections contain two or more bridges and/or railroad crossings, however, this assumption of randomness is not exactly true. This error, however, should not be serious. This method of sampling has the definite advantage of reducing travel costs for the collection of data required for a sample survey using the separate populations.

A much smaller travel, collection, and analysis cost will occur for the composite population than that required for the separate populations. Because only those bridges and railroad crossings located in the sampled highway sections are sampled, the data are somewhat easier to obtain. However, the information which is obtained from the composite population may have its limitations.

If estimates of bridge and railroad crossing improvements are desired, much larger sample sizes are required for comparable accuracy than are required for the separate populations. The decision to use this population should be made only after careful consideration has been given to the information desired from the sample and the costs of sampling from separate and composite populations.

Table III gives the costs required for sample surveys using simple random, stratified random, simple cluster, and stratified cluster sampling for total cost for a margin of error d_T = ten percent of the total and $\alpha = 0.10$ for the Michigan data. A comparison is made of sample survey costs using the separate and composite populations. From the costs given in this table, substantial difference in expended funds required for sample surveys using the separate and composite populations is evident. The cost of all forms of cluster sampling for the respective separate and composite populations is much greater than simple random or stratified random sampling. The large costs for all forms of cluster sampling is an additional indication of the unfeasibility of the county as a sampling unit for highway needs evaluation. Little difference in cost results for simple random and stratified random sampling. Stratified random sampling has a minimum survey cost of $10,300 for the separate populations, simple random sampling a minimum of $5,700 for the composite population.

TABLE III. COMPARISON OR SAMPLE SURVEY COSTS FOR THE SEPARATE AND COMPOSITE POPULATIONS

Type of Sampling	*Separate Populations*	*Composite Population*
Simple Random	$10,700	$ 5,700
Stratified Random, Optimum Allocation	10,300	5,800
Stratified Random, Proportional Allocation	11,000	5,900
Simple Cluster	35,000	30,900
Stratified Cluster, Optimum Allocation	24,500	20,000
Stratified Cluster $n_h \propto N_h$	32,000	27,500
Stratified Cluster $n_h \propto M_h$	28,500	23,000

CONCLUSIONS

1. Sample survey methods are feasible for the estimation of rural county primary highway needs for the estimate of total costs of highway, bridge, and railroad crossing improvements on a statewide basis.

2. Sample survey costs using a composite population are less than sample survey costs using the separate populations. However, the information which can be obtained from the composite population is more limited than the information which can be obtained from the separate populations.

3. The county is too large a sampling unit for the estimation of the total cost of improvements for the rural county primary road systems. A much smaller sampling unit such as the township would be more practical for cluster sampling.

RECOMMENDATIONS

From the preceding discussion it is recommended that sample survey methods be applied to future highway needs studies. The use of these methods seem especially practical for the estimation of needs on local road and city street systems as well as primary county roads. Simple methods can also be used to maintain highway needs studies on current bases so that recent and reliable data are available for future highway planning.

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